

FOREST SCIENCE PROGRAM ANNUAL REPORT 1999/2000



science to support sustainability



FOREST SCIENCE PROGRAM MISSION STATEMENT

"To help provide innovative solutions to high-priority forest management problems in British Columbia and to advance resource stewardship based on scientific principles"



Briefing college students, local residents, and small-business operators about pattern, process, and productivity in hypermaritime forests on Porcher Island in the Prince Rupert Forest Region, as part of the HyP3 project.

Cover: Integrating forestry and watershed processes is the topic of this year's feature article. The Kitlope Valley is an example of a coastal watershed.

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National Library of Canada Cataloguing in Publication Data

Forest Science Program (B.C.)

Annual report. - 1998/99.

Annual.

Running title: Forest Science Program annual report.

Issued by Research Branch.

Continues: British Columbia. Ministry of Forests. Research Branch.

Research Program annual review. ISSN 1192-4535.

ISSN 1492-1707 = Annual report - Forest Science Program
(Victoria)

1. Forest Science Program (B.C.) - Periodicals. 2. Forests and
forestry - Research - British Columbia - Periodicals. I. British
Columbia. Ministry of Forests. Research Branch.

SD14.B7B74

354.5'527'0971105

C00-960054X



JOINT MESSAGE FROM THE CHIEF FORESTER AND THE ASSISTANT DEPUTY MINISTER, OPERATIONS

British Columbia's diverse forested ecosystems provide a wide range of values that are of importance to our residents and to the global community. How well we perform as stewards of those resources affects not only the economic, social and ecological benefits that can be derived, but also the perceptions about our commitment to principles of scientifically sound sustainable management.

The 1999/00 fiscal year has been an especially challenging time for the forest sector. Increasing costs – primarily associated with stringent forest practices standards in the Forest Practices Code – coupled with market declines in Asia and continued trade restrictions on access to the U.S. market, have prompted both government and the forest industry to aggressively pursue greater efficiencies in all aspects of the forestry business. The need to reduce administration, trim costs, diversify products, maintain or enhance environmental standards, maintain timber supplies in the face of new parks and other non-timber resource demands, and respond to demands for certification are all individually challenging tasks. The need to address them all simultaneously, and to maintain a balance among them, adds a new dimension of difficulty. The Forest Science Program has contributed, and continues to contribute, much of the knowledge and expertise that allows the ministry to rise to those challenges.

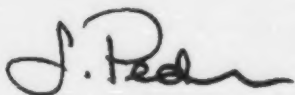
There is growing attention being paid in many jurisdictions to the importance of water, so it is timely to illustrate some of the scientific advances we have made in B.C., and to point to areas where new knowledge will improve our understanding of how to conserve this vital resource. A special feature in the 1999/00 Annual Report is an article showcasing the scientific basis for watershed management. Our water is both a resource in itself and an indicator of how upland resources are being managed. As a resource, water provides habitat for fish and domestic and agricultural water supplies, and it nurtures riparian habitats for plant and animal species. Changes in seasonal flow rate, sedimentation and temperature are indicators of sustainable management, and they send signals about the impacts of management practices on overall watershed health.

The Forest Science Program website, at www.for.gov.bc.ca/research includes detailed information about Research Branch and regional Forest Science activities. The site also provides publication lists, downloadable reports, and notes on current events and projects.

In the near future, we anticipate that increasing interest in forest management certification schemes will step up the demand for scientific evidence to verify sustainable forest management practices. The ministry's rich legacy of long-term research studies - providing that legacy is well maintained - will no doubt play an important role in efforts to supply locally relevant, high-quality scientific information that is based on B.C. ecological conditions and management considerations. Aside from what it can contribute to certification, long-term research information helps researchers define and validate appropriate criteria and indicators of sustainability. For example, our studies of native tree genetic architecture will be immensely valuable in helping predict and mitigate the effects of climate change on forest growth and yield.

Through a progressive program of scientific research, we will continue to pursue our goal of being the world's best managers of natural forests and range lands. New knowledge will be used to refine management decisions, which will reduce our margins for risk in integrating the multiple dimensions of resource production and use through time and space. That same knowledge is required for continuous improvements of policies and forest practices standards. Important questions remain to be answered about how much more intensively we can manage portions of the forest land base for timber and other goods, while still achieving the broad stewardship objectives of the Forest Practices Code. And, on other parts of the forest land base, how timber harvesting can be conducted with a "lighter footprint" that will not trample special conservation values.

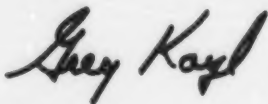
Although opinions vary widely about the appropriate uses of forests, especially the balance between conservation and economic objectives, there is widespread consensus that science forms the basis for sound practices.



Larry Pedersen

Chief Forester

Assistant Deputy Minister, Forestry Division



Greg Koyl

Assistant Deputy Minister, Operations Division

MESSAGE FROM THE DIRECTOR

During 1999/00, we increased our focus on the business side of the Forest Science Program. In keeping with the directions established through the Ministry of Forests Research Branch Strategic Plan, October 1998, and the preceding assessment of regional research operations, we continued our efforts to define priorities and allocate staff and financial resources to most effectively meet ministry needs. We also continued our work to improve corporate policies, standards, technical services, and management support systems.

The Forest Science Board, which was established in the fall of 1998, met twice during 1999/00, cementing a shared vision for the Research Branch and Regional Forest Sciences components of the Forest Science Program.

The board concluded that the Forest Science Program has made considerable progress in implementing a new, business focus, but it encouraged the program to increase its attention to assessing ministry needs and priorities, and on responding to them effectively - all while maintaining commitments to ongoing projects funded by Forest Renewal BC. This has required more flexible use of staff resources, beyond traditional roles and individual specialized knowledge, and much more dialogue and cooperation with clients. In some instances, it forced us to ask probing questions about what levels of work are necessary as opposed to desired, for maintaining ongoing research projects. Finally, the board's feedback generated much more cross-divisional dialogue among program staff.

The board plans to meet in the spring and the fall. The spring meeting will assess the past year's performance, and plans and resources for the coming year. The fall meeting will provide the program with strategic direction for performance plans for the following fiscal year. The fall meeting will also discuss matters of science, such as research progress on topical issues, and how to improve the two-way exchange among science and management and policy. The board's advice and support will be increasingly important over the next two years, as the ministry's strategic directions and business priorities align more closely with overall government directions, and as the ministry applies for new Science Council of B.C. funding to replace expired contracts.



A case study of the operational feasibility of partial cutting, in which a light cut (i.e., 30% removal) has been done in the Creston Community Forest.

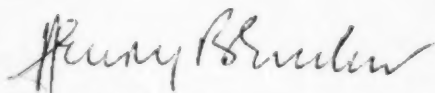
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The Forest Science Program must remain responsive to demands for new knowledge, but its ongoing business challenge is to find more secure ways to maintain the ministry's valuable long-term research installations, some of which date back to 1929. These installations are a valuable repository of information, such as progeny tests for tree breeding, growth and yield responses to silvicultural treatments, soil productivity, reference watersheds, silvicultural systems, and biodiversity. Distributed across the province, in various biogeoclimatic zones and subzones, these sites provide us with important benchmarks against which we can assess current practices, with excellent outdoor classrooms for training and education purposes, and, almost certainly, with the basis for addressing the questions of tomorrow as well as today.

In the coming year, we look forward to making considerable strides, in partnership with other science organizations, to improve our knowledge management systems. Our strategic planning process identified knowledge management as a deficiency that needs urgent attention. To fulfill our obligations as effective custodians of long-term scientific research knowledge, we must find new ways to access, transfer and question information to meet a wide variety of demands and a broad array of science user communities. Our program is not alone in this. Throughout Canada, there is a need for greater collaboration among science providers to ensure that systems are designed and implemented to more adequately meet current and expected future needs.

The ministry's Forest Science Program continues to be an active participant in numerous cooperatives, councils, partnerships, technical committees, and other groups at the regional, provincial, national and international levels. We also see positive progress in developing meaningful "co-producer" relationships with our many clients. Our ability to network within the scientific community has increased through electronic communication, and the opportunities for collaboration and sharing of resources are increasing as agencies try to do more with less. To this end, the ministry continues to actively participate in the Forest Coalition for the Advancement of Science and Technology (FORCAST) and the B.C. Committee of Forest Research Agencies (COFRA), which respectively represent organizations working at the national and provincial levels to champion forest-sector science and technology, and to promote greater collaboration and networking.

The significant accomplishments over the past year were achieved through the commitment, dedication, and sheer hard work of our staff. They have risen to the challenges of uncertain funding, changes in strategic direction and priorities, working more closely with clients, and being more accountable for their use of resources and their delivery of products and services.



Henry Benskin

Director, Research Branch

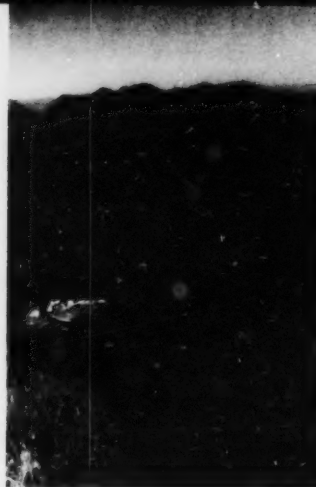
OVERVIEW OF THE FOREST SCIENCE PROGRAM

SUPPORTING
MINISTRY OF
FORESTS STRATEGIC
PRIORITIES

The Ministry of Forests is responsible for managing and protecting B.C.'s timber, range and outdoor recreation resources for the best balance of short- and long-term economic, social and environmental benefits for all British Columbians. Its strategic goals are to ensure stewardship of the forest and range resources, support forest-sector employment and community stability, enhance forest-industry competitiveness, and meet fiscal targets and improve business practices.

The Forest Science Program has contributed to the ministry's objectives in many important ways. Among those, it has:

- increased our understanding of how integrated management prescriptions can be achieved, and how the results will affect forest growth and yield,
- refined models and analytical procedures, which in turn help improve predictions of the resource-production implications of different management options,
- revealed new ways, through work in forest genetics and silviculture, to achieve higher productivity in future stands,
- contributed to the design of management prescriptions to achieve a variety of resource management objectives across the land base,
- helped refine sections of the *Forest Practices Code of British Columbia Act*, provided a scientific foundation for forest practices related to hydrology, soils, terrain stability, and ecosystem and density management, and played a lead role in producing or contributing to many code guidebooks and training packages, and
- continued to provide essential support for the chief forester in the Timber Supply Review process and decisions, principally by developing growth and yield models.
- expanded the knowledge base for production, sustainable management, and administration of timber supplies,



*A coastal watershed on
Vancouver Island, British Columbia.*

SETTING PROGRAM PRIORITIES

In British Columbia, research in the forest sciences is coordinated and guided by a number of committees, advisory boards, councils and partnerships. The Forest Science Board and advisory groups are the most significant in integrating external and internal requests for services, and in guiding the priorities and direction of the Forest Science Program.

The Forest Science Board is an internal, inter-divisional body that is co-chaired by the executive director, Operations Division, and the deputy chief forester, Forestry Division. The board reviews the annual plans and performance of the Forest Science Program before making recommendations about program priorities to the respective assistant deputy ministers. The director of the Research Branch provides Forest Science Program leadership at the provincial level and presents both branch and regional forest science accomplishments to the board.

Regional Forest Science Advisory Groups take various forms. They set priorities and provide direction for regional operations. The headquarters advisory process is delivered informally, through an ongoing, close working relationship between Research Branch managers and client managers in other branches.

ORGANIZATION

The Forest Science Program consists of the Research Branch, within Forestry Division, and six regional Forest Science Teams within Operations Division. For the Research Branch, 50 researchers work in a range of scientific disciplines. On a regional basis, 48 scientists also cover a variety of specialities and work closely with regional and district clients. Program scientists in all locations are supported by skilled technicians, extension specialists, statisticians, and computer, clerical and management personnel. The Forest Science Program is, above all, collaborative: operations staff in regional and district offices, other branches of the Ministry of

Forests, and external partners all provide invaluable assistance and contribute to the work of the program.

Research Branch staff work at the Victoria headquarters office and four research stations on the coast and in the interior, in two regional and one district office, and at the University of British Columbia. Regional and Forest Science staff are located primarily in regional offices, with one staff member in the Fort St. John Forest District.

Research Branch researchers work closely with policy-makers and the ministry executive in Victoria to provide a solid science foundation for policy development. Together with regional researchers, they undertake innovative research and provide technical support to regional and district operations staff to help them resolve complex operational issues associated with Forest Practices Code interpretation and implementation, silviculture, growth and yield, and timber supply. Regional scientists also advise on emerging front-line issues,



A Forest Science Program ecologist (centre) discusses research during a forestry tour with a German journalist (left) and a representative from the Bavarian Forest Owner's Association (right), in the Work Channel, Prince Rupert Forest Region.

often in partnership with the Research Branch, licensees, universities, the Canadian Forest Service, and others.

ACCOUNTABILITY

Forest Science Program managers are accountable to their senior manager clients in the Ministry of Forests for the selection of research topics and the assignment of staff and funds. This accountability is maintained through Regional Management Teams in the forest regions, through the Forestry Division Management Team in Research Branch, and through the Forest Science Board on a provincial basis.

For some areas of study, such as forest productivity and genetics research, the chief forester has established stakeholder councils to provide advice on strategic directions and business priorities. These councils, along with external funding sources such as Forest Renewal BC, also expect accountability from their partners, including ministry science staff.

CLIENTS AND PARTNERS

The Forest Science Program has a mix of internal and external clients. Internal clients,

who make up the majority, include the ministry executive and senior management, professional and technical specialists, and operational staff at all levels. External clients include licensees, other research organizations, public agencies, private industry, and the public.

To meet the program mandate of supporting ministry priorities, Forest Science staff meet both client requests for short-term problem solving and advisory services, and the ministry's corporate needs in anticipating and addressing emerging issues and opportunities through research. Research activities are also influenced by the formation of scientific partnerships and the availability of external funding. The program therefore responds to a broad range of client demands, from providing information and technical advice, to designing and implementing complex research projects.

The Ministry of Forests continues as a major partner in the Southern Interior Forest Extension and Research Partnership and the Northern

Forest Research and Extension Partnership. Both organizations are working to incorporate research results into operational practice, improve information sharing, and build cooperation among research organizations and the resource management community. Partners come from government agencies, industry associations, natural resource companies, First Nations groups, non-governmental organizations, Forest Renewal BC, and colleges and universities.

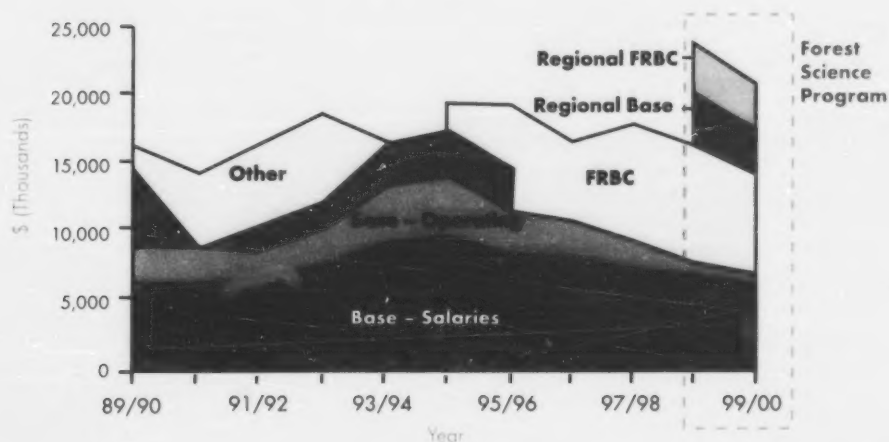
FOREST SCIENCE FUNDING

Ministry of Forests funding for the Forest Science Program continued to be supplemented by Forest Renewal BC funding in 1999/00, which represented approximately 48% of the total program (Figure 1). That supplemental funding allowed the ministry to initiate new research as well as continue its work on many long-term projects previously supported by the Canada - B.C. Forest Resource

Development Agreements (FRDA I and FRDA II).

Historically, ministry voted funding has principally covered essential fixed costs (i.e., most staff salaries, facilities maintenance, and a minimal amount of operating costs), and Forest Renewal BC funding has provided close to 85% of the overall operating funding for the program. Continued downward pressure on both the Ministry of Forests and Forest Renewal BC budgets has meant a decline in investment in the Forest

FIGURE 1: RESEARCH BRANCH FUNDING (ADJUSTED TO 1999 DOLLARS)



Includes only funding sources for Research Branch. The "Other" category includes funding from the South Forestry Reclamation Account (SMFRA), the Forest Renewal BC program funds from FRDA, and other external sources. Funding sources for the program are not included until 1996/97 when expenditures information was consolidated for the program.

Science Program. Figure 1 illustrates the breakdown of funding for the branch and program with the gradual decrease in resources.

The provincial Forest Science Program supported the equivalent of 189 full-time positions in 1999/00 in regional offices (30%), and at Research Branch headquarters (40%) and Research Branch decentralized locations (30%). Thirty-eight (20%) of those positions were funded by Forest Renewal BC.

EXPENDITURES

Forest Science Program expenditures were \$20.7 million in the 1999/00 fiscal year. This was a decrease of \$3.2 million from 1998/99. The proportion of expenditures across the major activity areas remained the same as it was in 1998/99: regional resources were concentrated on local operational issues related to ecosystem management, watershed management and terrain stability, and the demonstration and testing of silvicultural systems. Research Branch expenditures supported provincial programs in growth

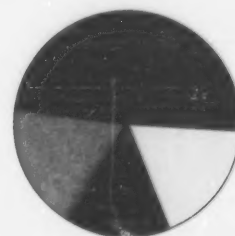
and yield, genetics and tree breeding, as well as provincial and regional initiatives in ecology, silviculture, and earth sciences.

In addition to the work undertaken within the Forest Science Program, research and development work is also conducted by other sections of the Ministry of Forests (e.g., by Forest Practices Branch and Resources Inventory Branch, among others). Details of those expenditures and accomplishments are not included in this annual report.

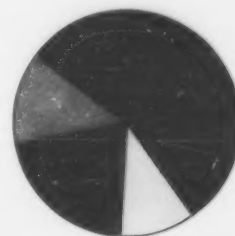
FUNDING TRENDS AND INITIATIVES

Provincial funding, from both the ministry vote and Forest Renewal BC, is expected to decline until possibly 2001/02. Forest Renewal BC plans to make a new call for research proposals later in 2000. With the completion of Forest Renewal BC-funded Research Program projects scheduled for the next fiscal year (i.e., 2000/01), the funding trend beyond that point will depend on the rate of success in the next call for proposals.

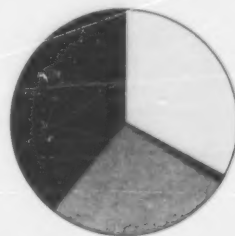
FIGURE 2: 1999/00 FOREST SCIENCE PROGRAM EXPENDITURES



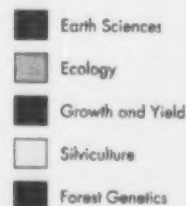
TOTAL FOREST SCIENCE PROGRAM, \$20.7M

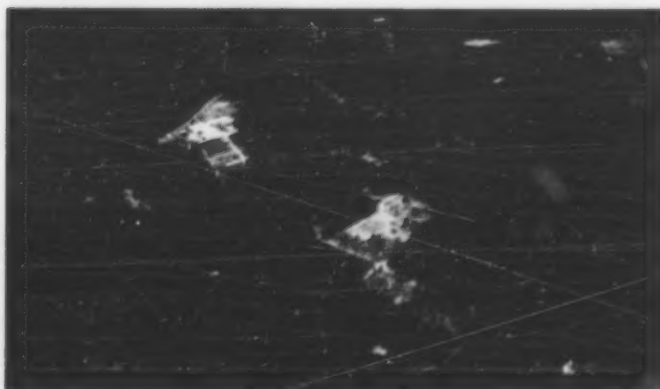


RESEARCH BRANCH, \$13.8M



REGIONAL RESEARCH, \$6.9M





Forest research has been ongoing at the Cowichan Lake Research Station since 1929.

Internally, the Forest Science Program is looking at efficiencies to reduce overhead costs. The Glyn Road Research Station was closed, and the Red Rock station is scheduled to close in 2000/01. Some staff and experimental equipment from these stations are being relocated to other sites. The Cowichan Lake Conference Centre, which is part of the Cowichan Lake Research Station, was set up as a separate cost-recovery centre for 2000/01.

Externally, the ministry, as a member of the provincial Committee of Forest Research Agencies (COFRA), has been involved in a project to increase awareness of science and technology in the forest sector. At the national level, the Forest Coalition for the Advancement of Science and Technology (FORCAST), which is comprised of government and non-governmental organizations across Canada, also champions the importance of forest-sector science and technology.

Coastal ministry staff have also been working with Forest Renewal BC to establish a Coastal Forest Research and Extension Partnership similar to the Southern Interior and the Northern Forest research and extension partnerships. Collaboration among researchers, clients and funding organizations will also increase the level of research that can be done.

Increasing demands on government budgets make it more and more difficult to secure funding for forest science research. At the same time, however, both internal and external drivers continue to create demands for science-based information to support sustainable forest management.

INTEGRATING FORESTRY AND WATERSHED PROCESSES



Forests play a vital role in maintaining natural water flows and water quality. Forests are also critical in regulating hillslope stability and ensuring stream channel integrity. Trees intercept precipitation, which alters both the amount of water that reaches the soil and the rates at which snow accumulates and melts, so removing trees may alter the magnitude and timing of peak flows in stream channels. Forests play a significant role in maintaining the slope stability of wet, mountainous soils. In the past, when roads and harvesting were placed in inappropriate locations, there were order-of-magnitude increases in landslide rates and sediment delivery to streams. As consequence, there were changes to flow and sediment-loading in stream channels, which adversely affected their stability. By removing trees and large woody debris, past forest harvesting of streamside areas jeopardized stream bank integrity and channel roughness, and contributed to widened and unstable rivers and reductions in fish habitat. Both demonstrated more careful riparian forest management practices are needed.

How a particular watershed responds to disturbance is governed by its past disturbance history, biogeoclimatic zone, and stream channel and hillslope characteristics. It is also governed by the management practices carried out in it,

NATIONAL Forests and Watershed Assessment

- Why is the Ministry of Forests studying watershed processes?
- What effects do forestry practices have on watersheds?
- How will research change our management of watersheds?

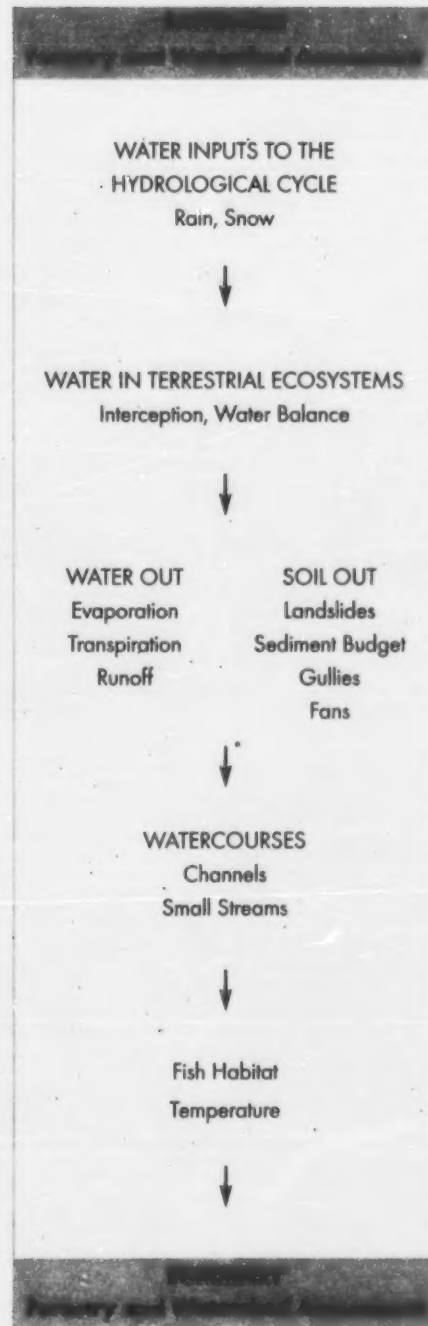
FEATURE ARTICLE

so forest managers need to understand the downslope, runoff and streamflow consequences of forestry activities, so that they can modify their plans accordingly. By recognizing and avoiding unstable terrain, using appropriate harvesting systems, and carefully designing, constructing and maintaining roads, forest land can be managed to substantially reduce the likelihood of landslides.

Developing the best watershed management practices requires that we first study the nature of, and the relationships between, the various parts of the hydrological cycle. We need to know how excess water is generated in forest stands. We need to know more about the mechanisms of water flowing over and through the soil, where sediment is generated in the landscape, and how sediment enters stream channels.

Researchers are currently working in the various hydrological zones of British Columbia to better understand the natural and disturbed pathways of water and sediment, as well as the responses in stream channels, fish habitat, and water quality and quantity.

Knowledge from watershed research is used to plan sound forest development at the site and landscape levels, both to ensure sufficient forest retention on sensitive sites, and to help forest planners design better forest road networks. Understanding these processes will also help planners focus watershed restoration work on the areas and individual watersheds where it will have the most significant benefits.



FEATURE ARTICLE

BACKGROUND

WATER INPUTS TO THE HYDROLOGICAL CYCLE:

Rain, Snow

WATER IN TERRESTRIAL ECOSYSTEMS:

Interception, Water Balance

WATER OUT:

Evaporation, Transpiration, Runoff

Water becomes part of the terrestrial hydrologic cycle when it falls as rain or snow. Whether precipitation falls as one or the other depends on the location, elevation, climate and time of year. Not all of the precipitation falling on a watershed reaches the ground. In mature forests, between 20% and 30% of the precipitation does not make it to the forest floor; it remains on leaves and branches or is absorbed by material in the canopy. From there, it evaporates directly back to the atmosphere. When trees are harvested or defoliated by fire, insects or disease, more total precipitation reaches the ground. For example, in clearcut areas, more snow accumulates on the ground, and that snow may melt more quickly than snow on the ground that is shaded by the standing forest.

Rain that reaches the ground either infiltrates the soil, where it is stored or drains to streams, or moves on the surface as overland flow to streams. Water can be delivered very quickly to streams, depending on the length and volume of the rainfall, the soil moisture conditions prior to the fall, and the geology of the watershed. Snow, on the other hand, accumulates on the ground over the winter,



Moffat Creek is important fish habitat. It flows through private agricultural land and into the Horsefly River.

storing water that only becomes available to runoff during warm rains in the winter months, or as the weather warms in spring. The snowmelt infiltrates the soil and gradually moves downslope into stream channels. As water moves downslope, some is intercepted and diverted by roads, or is taken up by trees and transpired into the air. Harvesting trees tends to decrease evaporative and transpirational water loss so that more water reaches the stream channel, thereby increasing streamflow. Peak flows are also increased by greater snow accumulation and snowmelt rates.

Water balance is an expression of the water present in the forest root zone: it depends on the balance between water input and output. Water input is the total precipitation less the precipitation lost due to canopy interception and surface runoff. Water output is water lost by soil surface evaporation or drainage, or by plant transpiration. Transpiration and evaporation from the soil surface depend on canopy cover. In a mature forest, soil evaporation is a minor component of the water balance. By contrast, in a harvested

FEATURE ARTICLE

area, soil evaporation is significant for the first year or two, although over the year less water is lost than would have been transpired by the harvested trees. Transpiration loss increases as the vegetation of the new forest develops, and, relatively early on, it may reach values similar to those of the mature forest. However, interception by the canopy does not recover as quickly as transpiration from the canopy, so, for a number of years, more water is available for drainage from the root zone than in the mature forest.

SOIL OUT: Landslides, Sediment Budget, Gullies, Fans

In steep mountain landscapes, hillslope failures such as debris slides and debris flows are the dominant process of surface change (i.e., the geomorphic process). A debris slide is a "dry" landslide with low water content. A debris flow is a type of landslide made up of water, sediment and woody debris such as logs or trees, flowing downhill at high rates of speed, and usually affecting streams. Most of the geomorphic changes in watersheds take place during large-magnitude storms: debris and sediment are transported to streams, causing channel changes. Slope failures can result in the loss or destruction of forest site productivity, water quality, and stream habitat.

Sediment can be divided into two general categories. Fine sediment (i.e., fine sand, silt and clay) is carried in suspension by streams. Suspended sediment causes turbidity or cloudiness in water, and is the main water-quality concern related to forest development

in watersheds that supply community and domestic water. Unless there are lakes in the system, there is very little storage of suspended sediment, so what is produced at sediment sources in the watershed is carried quickly to the stream's mouth or to the users' water intakes. Coarse sediment (i.e., coarse sand and gravel) is carried by streams as bedload. The capacity of streams to carry bedload is often limited at all but the highest flows. Therefore, most bedload produced in a watershed is stored in the channel, often for decades or even centuries, and most bedload movement takes place during flood events. The storage and movement of coarse sediment in channels, and the channel structures that are created, are of critical importance to fish habitat.

A sediment budget quantifies the input, storage and output of sediment in a stream channel. It is used to monitor changes to aquatic habitat, water quality, and other important watershed attributes.

Changing the nature of sediment production and storage can also adversely influence fish habitat, primarily by changing spawning, incubation and rearing environments. Each of these can be affected by the wide range of sediment sizes generated by certain forest development practices. Constructing watershed-scale sediment budgets is the primary way to identify links between fish habitat and forestry activities.

Gullies are steep channels on hillslopes. They have both hillslope and channel characteristics, and are the starting zone for many landslides and debris flows. From these

FEATURE ARTICLE



An S5 stream in an unlogged forest, upstream from a clearcut. Shade (i.e., angular canopy density) equals 61% at this point.



The same stream, 600 metres downstream in the clearcut: here the shade equals 23%.

areas, sediment and woody debris are often discharged directly into valley-bottom streams – which may also be fish habitat – and form alluvial or debris-flow fans. Open-slope landslides can enter gullies and come in direct contact with fish habitat. Instantaneous water flows in gully channels can also transport large amounts of sediment and woody debris into valley bottoms.

Alluvial fans are cone-shaped deposits of sediment that are formed where a stream or gully emerges from the confines of a hillslope. A central feature of most alluvial fans is that they have one or more unconfined stream channels. Characteristically, alluvial fans are associated with high-productivity forest sites and, because they are easy to access and have relatively gentle gradients, offer low-cost timber harvesting opportunities. However, alluvial fans are often continually changing, because of the active hydrogeomorphic processes (e.g., flows and landslides) that are present in the watershed and on the fan. Forestry activities such as harvesting and

road-building on a fan or in the contributing watershed can destabilize fans. For example, landslides frequently deliver sediment directly to the stream channel, which can cause the channel to change at the point of entry, and at any point downstream. One of the most sensitive parts of the stream channel is the fan. The addition of sediment from landslides can cause the stream to wander on the fan. Roads on fans can intercept surface and sub-surface water, leading to rapid erosion and channel movement.

WATERCOURSES: Channels, Small Streams, Fish Habitat, Temperature

Stream channels are fundamental features of all watersheds. They channel surface water and transport inorganic sediment, nutrients, woody debris, and fine organic materials from headwater areas, downstream through interconnecting channels, and ultimately to the mouth of the main stream. This drainage network also contains unique riparian and aquatic biological communities. The condition

of these streams and communities can be dramatically altered by forest practices.

Small streams are a high management priority, because they are found throughout watersheds, often as small tributaries that link steeper headwater areas of a drainage basin to the larger, lower-gradient streams found downslope. Forestry activities moving from the lowlands toward the crest of a watershed encounter progressively smaller streams, so the cumulative effect of many minor activities spread throughout the watershed must be carefully considered to avoid major effects on stream environments.

Freshwater habitats for fish and other aquatic organisms are linked, to varying degrees, to both riparian and upland forest ecosystems. Forest practices can affect fish habitat by altering organic and inorganic sediments, large woody debris, and the availability of organic litter, nutrients, and invertebrate food organisms. The effects on fish populations and habitats can be direct (i.e., at fish habitat sites), or indirect (i.e., in small tributary streams that flow directly into fish habitat areas).

Like all other hydrologic variables, stream temperature varies in both space and time. In the summer, when stream temperature is of most concern for fish, the coolest water tends to be found in headwaters, and the warmest in valley bottoms. This is because streams in headwater areas are made up of recently emerged groundwater, which is close to the mean annual temperature. Snowmelt makes headwater streams even cooler in areas with late-lying snow. As the water flows downstream, it warms

from contact with the air and, more importantly, from exposure to sunlight.

As streams widen in the downstream direction, the shade provided by riparian vegetation decreases, and streams warm up naturally. In the largest streams, such as the Fraser River, riparian vegetation does not provide effective shade, so summertime temperature is mainly a function of river discharge and the weather. However, in smaller streams, vegetation can provide a substantial amount of shade, so the management of riparian vegetation is important.

RESEARCH

WATER INPUTS TO THE HYDROLOGICAL CYCLE: Rain, Snow

A range of research projects is underway to answer questions about how forest removal and regrowth affect the amount of rain and snow that reach the ground. Prior to approving logging plans, forest planners must assess the potential effect of current and past forest harvesting on the water resource. Forest harvesting has the potential to increase streamflow, which can accelerate the processes of stream channel erosion and sediment movement. Since the highest streamflows in many watersheds are caused by melting snow and rain on snow, it is important to understand the relationships between forest cover, the amount of snow that accumulates, and the rate at which it melts.

Coastal research is focusing on changes in rainfall interception, snow accumulation, and

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snowmelt following clearcutting and partial cutting in maritime forests. Research in the Cariboo Forest Region is investigating the effects of group selection in high-elevation forests, and in the Kamloops and Nelson forest regions, the interactions between stand structure and snow accumulation and melt. Preliminary findings in the Cariboo Forest Region indicate that at a constant 30% volume removal, openings of several tree heights in diameter accumulate more snow than the forest does, with the amount of extra snow increasing as openings get larger. On north-facing slopes, researchers found that snow remained on the ground longer in the spring, reducing the length of the growing season for trees on the site. In the Kamloops and Nelson forest regions, research has shown that significantly different patterns of snow accumulation and melt occur in clearcut, juvenile and mature stands, and in stands of different species. In the Vancouver Forest Region, snow accumulation and melt rates in clearcuts have been found to be twice that of the rates in old-growth forests. Measurable reductions in both snow accumulation and melt have been found in regenerating forests of between 8 and 14 metres tall.

The relationships between stand structure and snowpack processes are being incorporated into hydrologic models and other planning tools. This will help researchers and forest managers understand fundamental hydrological processes and more accurately predict the effects of forest practices on the hydrologic cycle.

Cooperators

Weldwood of Canada Ltd., Weyerhaeuser Canada Ltd., and Forest Renewal BC.

WATER IN TERRESTRIAL ECOSYSTEMS

Interception

WATER OUT: Runoff

WATERCOURSES: Channels (Streamflow)

To help develop soil water-balance models, research is being conducted at Upper Penticton Creek in the Kamloops Forest Region, and at Carnation Creek and the Cowichan Lake Research Station in the Vancouver Forest Region. Specifically, researchers are measuring the interception of rain and snow, snowmelt, evaporation, and soil water content in forests of different ages. These data are being used to model the physical relationships between biotic (i.e., living) and abiotic (i.e., not derived from living organisms) site factors, and to generalize these relationships to other sites.

Research on runoff is taking place at Upper Penticton Creek in the Kamloops Forest Region, Roberts Creek in the Vancouver Forest Region, and Redfish Creek in the Nelson Forest Region.

The Penticton study is a classic paired-watershed experiment, in which sets of watersheds are monitored for a number of years so that streamflow can be predicted in the treatment watershed, based on a separate control that is not part of the treated pair. When the paired watersheds have been calibrated, one watershed is harvested, and

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the effects are measured. At Upper Penticton Creek, natural streamflows, weather patterns and water quality were measured for 10 years prior to harvesting. Researchers are now studying how harvesting 20% of the forested area affected two treatment watersheds, compared to the unharvested control. At Roberts Creek, natural streamflows, groundwater levels, weather patterns and water quality were measured for four years prior to harvesting. Researchers are now studying how a variable retention harvest in one treatment watershed, and a 50% strip shelterwood in a second treatment watershed affect peak streamflow, water chemistry, turbidity and water temperature, as compared with the unharvested control. A modelling approach will be used in conjunction with the standard paired-watershed approach to gauge the effects of the treatments.

In the Redfish Creek watershed, hydrologic modelling is being used to estimate the effects of 10 different harvesting patterns. Actual changes in streamflow can be measured in paired watersheds, but the modelling approach is often preferable because it allows researchers to compare various harvesting patterns that would be impractical to achieve in a paired-watershed study.

Quantitative information on the effects of harvesting on streamflow is essential for sound forest planning, particularly when harvestable timber lies within community watersheds. That is the case in the Kamloops and Nelson forest regions, where the watersheds not only provide water to downstream communities, but include

approximately 10% of the total harvestable timber in the area. Forest researchers took a research rather than a monitoring approach to provide quantitative information to planners on the effects of timber harvesting. Such data more clearly illustrate harvesting impacts, so that their effects on streamflow can be appropriately regulated and more easily documented for community water users.

The results of watershed research are used to guide daily forest operations and create land-management guidelines. Results are also presented to other scientists, field staff, students and others interested in hydrology. The recently published *Interior Watershed Assessment Procedure Guidebook*, for example, helps forest planners assess the cumulative effects of land use in a watershed. The proceedings from the Interior Watershed Management conference held in Penticton, B.C. in March 2000, will document much of the recent research. Information on interior watershed management is also updated regularly on the Internet.

Cooperators

The University of British Columbia, Weyerhaeuser Canada Ltd., the University College of the Cariboo, the Water Survey of Canada, and the B.C. Ministry of Environment, Lands and Parks.

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Servicing a climate station in winter.

WATER IN TERRESTRIAL ECOSYSTEMS: Water Balance

Understanding changes in site water balance helps forest planners minimize the risk of adverse effects on streams from timber harvesting. Removing forest cover can increase the amount of water available to drain to streams or transport sediment from harvesting sites. Information about the recovery of precipitation, interception, and evaporation as functions of stand characteristics (such as height and crown depth) is helping forest managers maintain the hydrological balance of watersheds.

Site water balance studies are one important component of watershed research. Results at the watershed level are incorporated into forest operations and land-management guidelines. Results are also presented to scientists, field staff, students and the public, in the classroom and the field, and on the Internet.

Cooperators

The University of British Columbia, Weyerhaeuser Canada Ltd., and the City of Penticton.

SOIL OUT: Landslides

Landslide research in the late 1970s and early 1980s established that the occurrence of landslides can be affected by timber harvesting and road-building. Current research is concentrating on developing solutions or solving problems related to the management of landslide-prone terrain.

Research has provided insight into the causes of landslides and the factors that contribute to them. For example, researchers have linked drainage capture from roads to a landslide at Donna Creek northwest of Mackenzie, and runoff changes caused by harvesting to the hydrology of the initiation zone of a major debris flow east of Kelowna. These findings have helped forest managers modify management practices on steep hillslopes.

Studies to characterize and describe unstable terrain are ongoing in all forest regions in British Columbia. Researchers are quantifying landslide frequencies and studying the terrain factors that contribute to landslides. Results are being used to calibrate the Terrain Stability Mapping classification that is used by the B.C. forest industry, and to provide geotechnical information on landslides for engineering applications.

To define precipitation thresholds for hazardous conditions, researchers are



Debris avalanches in a clearcut near Shelly Creek in Rennell Sound on the Queen Charlotte Islands.

Note the historic failures, which appear as long, linear strips of Sitka spruce and red alder, in relation to more recent failures.

collecting precipitation data, studying soil drainage rates, and identifying storms related to historical slope failures. Defining the critical limits for potentially hazardous conditions is important in reducing the possibility of workers being involved in landslides during rainstorms and under wet soil conditions.

SOIL CUT: Sediment Budget

In many regions of British Columbia, the main water source for urban and rural communities is surface water from watersheds in the provincial forests. Concern over the effects of forest development on water quality has prompted several research studies on sediment budgets.

In the Nelson Forest Region, several research projects involving sediment budget studies are underway in the West Arm Demonstration Forest, and on creeks in the Arrow and Cranbrook forest districts. In the Vancouver

Forest Region, a sediment budget study is underway at Russell Creek in the Tsitika River watershed, a typical northeast Vancouver Island watershed with important fisheries values.

These studies have found that:

- streams used for community water supply in the southern interior of B.C. typically have extremely low natural sediment yields, while the more geomorphically active Vancouver Island watersheds tend to produce large but short-lived peaks in suspended sediment during storms,
- suspended sediment yields can be increased by forest development, however, in most cases in interior watersheds, water turbidity remains well within water quality standards during all but a few weeks during spring floods,
- roads are the most significant source of development-related sediment – at Russell Creek, between 8% and 30% of the sediment production during storm events was derived from road crossings – while clearcuts and harvesting activities rarely produce a measurable increase in sediment, and
- there are important differences in the susceptibility of different watersheds to increased sediment from forest roads. These differences are the result of watershed geology and soils, and the relative importance of surface and subsurface flow in generating runoff.

As a result of these studies, improvements have been made to the Watershed Assessment Procedure, and operational monitoring procedures of water quality in domestic-use watersheds have been made more efficient. Methods have also been improved for mapping and assessing the erosion potential of forest roads, and for including surface erosion hazard ratings in terrain mapping.

Cooperators

The Canadian Forest Service, the City of Cranbrook, and Galloway Lumber Co. Ltd.

SOIL OUT: Gullies

Landslide frequency studies in the Queen Charlotte Islands, on the west coast of Vancouver Island, and in the Coast and Cascade mountains on the B.C. mainland consistently show that gullied terrain has some of the highest landslide rates in logged areas. This high landslide rate is probably due to the concentration of rainfall and snowmelt within the soil profile, and the very steep slopes that often characterize gullies.

A recent study in the Vancouver Forest Region examined the factors that are likely to cause debris flows in gullies, since this is where they frequently start. Researchers found that most debris flows start as a small or moderate-sized "dry" debris slide. When the debris slide reaches the gully channel, it can develop into a debris flow. Slides from headwall locations were found to be

particularly likely to develop into a debris flow, while slides from sidewalls are much less likely to do so. Researchers also discovered that larger debris slides are much more likely to develop into debris flows than are small debris slides, and steeper channel gradients are more likely to result in debris flows.

This work is incorporated in the Forest Practices Code *Mapping and Assessing Terrain Stability and Gully Assessment Procedure* guidebooks.

Cooperators

TimberWest Forest Ltd. was a partner in the debris flow initiation study. Funding for some of the studies was provided by Forest Renewal BC.

SOIL OUT: Fans

Fans are a key component of watersheds, which have historically been overlooked by forest researchers. A great deal of research has been conducted in natural and managed watersheds on hydrogeomorphic processes that directly influence fans (e.g., debris flows, sediment budgets, and vegetation response to hydrogeomorphic events). This research, however, has not yet been integrated to assess the hazards of forest activities occurring on fans. Current research is focusing on documenting the forest-stand characteristics and geomorphic features of fans, along with the geomorphic and geologic features of their contributing watersheds. Researchers and planners will use this information as the basis of a hazard classification for forest activities on fans and in

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their watersheds. The classification will be tested retrospectively on fans where forest management activities have already taken place.

Products from the research to date include an extension note and a draft management strategy for forest management and restoration on fans in the Prince Rupert Forest Region. Field training sessions have been held in Houston, Smithers and Terrace to introduce the strategy to operational and planning staff. A district manager's policy is in place in the Kalum Forest District to address forestry activity planning on fans.

Cooperators

The Department of Fisheries and Oceans, the B.C. Ministry of Environment, Lands and Parks, the University of British Columbia, Simon Fraser University, Skeena Cellulose Inc., and West Fraser Mills Ltd.

WATERCOURSES: Channels (Stability and Channel Bed)

Watershed studies linking terrestrial and aquatic systems have been ongoing in coastal and interior areas of British Columbia to better our understanding of the interactions among forestry practices, the physical and biological processes in watersheds, and the long-term recovery of terrestrial and aquatic systems to their pre-disturbed states. These long-term studies are located on Vancouver Island (at Carnation Creek, from 1970 to the present), on the Queen Charlotte Islands (from 1982 to 1994), and in the Stuart-Takla

watershed in the north-central interior (from 1990 to the present).

Information from these studies has contributed to the riparian, stream channel, and fish habitat protection provisions of the current Forest Practices Code. Several code guidebooks are also based largely on these studies (e.g., the *Watershed Assessment* and the *Channel Assessment* procedures, and the *Riparian Management Area* and the *Fish Stream Identification* guidebooks). These studies have also provided important baseline information for Forest Renewal BC's Watershed Restoration Program, and for evaluating the effectiveness of its rehabilitation treatments.

By understanding the processes that link terrestrial and aquatic systems, researchers have enabled the rehabilitation of hillslopes, stream channels, and aquatic habitats that were affected by forestry activities prior to the introduction of the Forest Practices Code.

Cooperators

The Department of Fisheries and Oceans, the Canadian Forest Service, the Department of the Environment, the B.C. Ministry of Environment, Lands and Parks, the B.C. forest industry, and several universities. Funding has been provided by project partners, Forest Renewal BC, and past federal-provincial initiatives such as the Canada - B.C. Partnership Agreement on Forest Resource Development (FRDA II).

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WATERCOURSES: Channels (Temperature)

Recently, forest managers have indicated a need for management guidelines for stream temperatures which can be an important factor affecting aquatic organisms in some streams. Researchers and forest planners need better ways to determine whether stream temperature is important for aquatic organisms and communities in a given stream. Forest managers need practical ways to protect stream temperature in cases where it is should be managed. Research and adaptive management projects are in place to help determine how to predict changes in stream temperature and develop practical methods for designing riparian buffers for shade retention.

Researchers in the Cariboo Forest Region are identifying and describing the processes that control stream temperature, to help planners make better decisions about riparian management. Working with an instrument that measures stream shade, they are characterizing shade along logged and unlogged streams. Information from this study has been used by the ministry's Temperature-Sensitive Streams Working Group, which is developing management guidelines to help identify and manage temperature-sensitive streams.

In the Prince Rupert Forest Region, researchers working in the Kispiax Forest District, exploring the influence of forest harvesting and roads on stream temperatures, found that slow-moving water in ditchlines is a



*Lower
Woodjam Creek,
a tributary of
the Horsefly
River, flows
through private
agricultural land.*

significant heating factor. As a result, the ministry's Small Business Forest Enterprise Program has increased the number of cross-drains that are used to disperse ditchline water. In another research project, researchers in the Morice Forest District are developing guidelines to improve the design of riparian reserves so that there are no net increases in stream temperatures. A new instrument developed by researchers in the Cariboo Forest Region is being used in this project to identify and quantify sources of shade for streams during the hottest period of the summer.

Carnation Creek on the west coast of Vancouver Island has been the site of a fish-forestry interaction study for 30 years, and stream temperature has been one of many topics that researchers have studied. Increased temperatures associated with riparian logging have been found to accelerate the growth and seaward migration of coho salmon. Since there has not been an increase in the numbers of returning coho adults, this accelerated development is not

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necessarily beneficial for the coho population. Stream temperature and fish production will continue to be monitored as the riparian canopy slowly grows over the channel.

The Carnation Creek study has historically provided the most comprehensive understanding of the physical and biological processes operating within a small coastal watershed in B.C. Work on the study has yielded a range of benefits, products, and technical support for integrated forest management, practices and policy. Among those have been:

- the British Columbia Coastal Fisheries Forestry Guidelines (1987 to 1995),
- the Forest Practices Code of British Columbia (1995 to present):
 - technical and scientific support for regulations and guidebooks, particularly riparian and aquatic habitat standards and practices,
- nearly 200 publications from the research, and
- part or all of 16 university theses.

Cooperators

Carnation Creek study: Historic partners included the federal Department of Fisheries and Oceans, which initiated the study in 1970, Weyerhaeuser Canada Ltd. (formerly MacMillan Bloedel Ltd.), the federal Department of Environment, Canadian Forest Service, and others (see below). The Ministry of Forests is now the lead agency on this project, with current funding coming predominantly from Forest Renewal BC.

Other current cooperators include:

- the University of British Columbia
- Gordon Hartman, Consultant Scientist, Nanaimo
- the B.C. Ministry of Agriculture, Food and Fisheries (BC Fisheries)
- the B.C. Ministry of Environment, Lands and Parks
- the Huu-ay-aht First Nation
- Bill Pollard, Consultant Biologist
- the Water Survey of Canada
- the University of Western Ontario

Kispiox and Morice forest district studies:

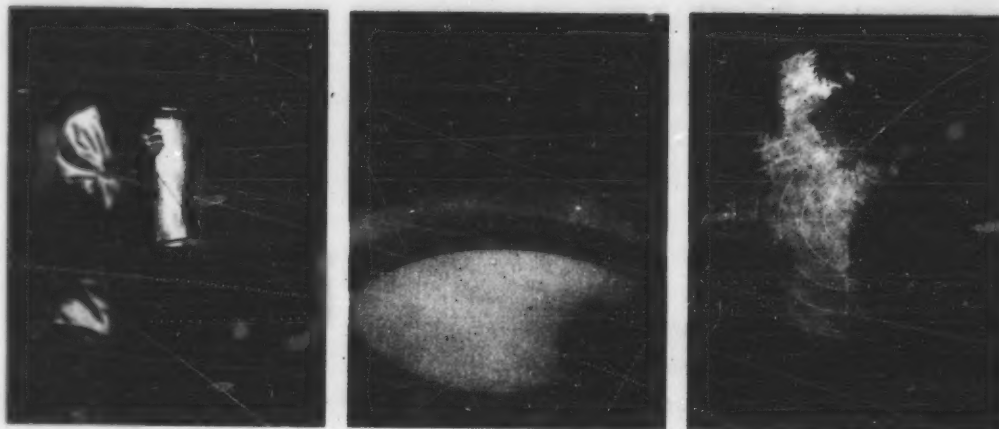
- the B.C. Ministry of Environment, Lands and Parks
- Houston Forest Products Co.

WATERCOURSES: Small Streams

Past controversy over the management of small streams in B.C. stems from an incomplete understanding of the role that streamside vegetation plays in maintaining channel integrity, moderating water temperature and providing nutrients for aquatic organisms. How small headwater streams contribute to stream channel and aquatic habitat characteristics of larger channels in valley bottoms has also not been well understood.

To help address those gaps in our knowledge about stream management, a research project was begun in 1995 in all biogeoclimatic zones to determine the role that large woody debris plays in small streams running through old-growth ecosystems. The goal of the project, which is ongoing, is to determine the

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(Left) Testing an instrument for measuring stream shade (i.e., angular canopy density). (Centre) The operator's view with a shade-measuring instrument showing the sun position at 1:00 p.m. Pacific Standard Time on August 1. (Right) A fish-eye photo of the forest-canopy with polar coordinates and sun paths for July 15 and August 15 at Williams Lake, B.C. superimposed.

origin of woody debris (e.g., from immediately adjacent to the stream or from landslides originating far upslope), where and how the debris is stored in the stream, and how often and how far it moves over time.

Results to date have helped improve existing best management practices in the Forest Practices Code. Changes are also expected to the Watershed Assessment Procedure, the Channel Assessment Procedure, the Gully Assessment Procedure and the Riparian Management Area guidebooks.

Cooperators

The Department of Fisheries and Oceans, the Department of Natural Resources (Canadian Forest Service), the Department of the Environment, the B.C. Ministry of Environment,

Lands and Parks, the B.C. forest industry, and several universities. Funding has been provided by project partners, Forest Renewal BC, and past federal-provincial initiatives such as the Canada - B.C. Partnership Agreement on Forest Resource Development (FRDA II)

WATERCOURSES: Fish Habitat

Research on aquatic habitats and fish has, in many studies, been integrated with studies on watershed hydrology, hillslope processes, sediment and large woody debris budgets, stream channel morphology (i.e., the study of shape and form in organisms), and water temperatures. The results of these studies have helped develop, validate and refine current forest practices, and watershed and stream channel restoration practices.

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In the Carnation Creek study referred to earlier, researchers are following the effects of pre-Forest Practices Code activities on fish and aquatic habitats, and the natural rates of watershed and fish habitat recovery after timber harvesting. Results from this project have revealed the complexity of fish-forestry relationships. Physical effects on the stream channel have caused a 50% reduction in both the survival of salmonid eggs and the abundance of juvenile salmonids that can be supported by the stream. However, increased water temperatures due to harvesting have accelerated egg development and hatching, promoted fish growth in summer, and increased the rates of overwinter survival. Carnation Creek consequently produces one-and-a-half more coho salmon smolts after logging than it did before. Counteracting these effects, higher temperatures have caused earlier smolt migrations in spring, which in turn have resulted in decreased marine survival and fewer adult coho salmon returning to spawn. These changes to habitat and temperature have persisted for 18 years into the post-harvest period.

Complementing the single-watershed case study information from Carnation Creek, multi-watershed retrospective studies in the Queen Charlotte Islands have generated information about watersheds characterized by steep, unstable terrain. The effects of roads and forest harvesting on the frequency of landslides, debris flows, and other mass wasting processes have been studied in the stream channels and fish habitat of 26 watersheds. Researchers have also

evaluated the effectiveness of a variety of stream channel rehabilitation techniques and structures in restoring degraded fish habitats. More recently, a long-term, paired-watershed study has been established in the Stuart-Takla area of the central B.C. interior to generate fish-forestry information.

In both coastal and interior locations, researchers are focusing on the role played by small headwater streams, as they relate to the whole watershed and to fish habitats located downstream. The effects of riparian harvesting on water temperatures in small tributaries are of particular concern. Researchers are studying the related effects of increases in water temperature on temperature-sensitive streams and fish habitat and species, particularly in the central and southern interior (see the preceding section, WATERCOURSES: Small Streams).

Cooperators

The Department of Fisheries and Oceans, the Canadian Forest Service, the Department of the Environment, the B.C. Ministry of Environment, Lands and Parks, the B.C. Ministry of Agriculture, Food and Fisheries, the B.C. forest industry, and several universities. Funding has been provided by project partners, Forest Renewal BC, and past federal-provincial initiatives such as the Canada - B.C. Partnership Agreement on Forest Resource Development (FRDA II).

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SUMMARY: Forestry and Watershed Assessment
Understanding watershed processes will help us manage our watersheds and sustain our forests.

In some instances, timber harvesting and road construction can significantly alter both the amount of precipitation that reaches the forest soil and the rate of accumulation and melt of snow. Forest roads can also intercept surface and subsurface flow, and both concentrate and redirect it. These local increases in water may initiate landslides and debris flows. Particularly in wet, mountainous areas, landslide rates can be as much as 10 times that of natural rates (i.e., in undisturbed areas). Depending on the amount of

development, peak flows in streams may also be increased. The sediment budget of a watershed can be altered by fine sediment that is generated episodically from road networks, and by the accelerated delivery of coarse sediment from landslides and gullies. Stream channel equilibrium will be disturbed by an increase in sediment and flow. Where streamside vegetation has been removed, dramatic stream channel changes may occur in some channel types, and the effects may persist for more than 40 years. Alterations in stream temperature may also persist until the riparian canopy closes.

Forest development and management can be designed to minimize these effects. Our understanding of these relationships between



Nancy Greene Lake, near Trail, B.C.

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forest activities and watershed processes has been incorporated into a number of Forest Practices Code guidebooks (e.g., *Watershed Assessment*, *Gully Assessment Procedure*, *Community Watersheds*, *Mapping and Assessing Terrain Stability*, and *Riparian Management*), all of which are updated as we learn more. The information has also been incorporated into the planning and priority-setting guidelines for Forest Renewal BC's Watershed Restoration Program.

Research priorities for the immediate future include:

- extending our understanding of site-level processes to the landscape and watershed scale, and of the effects of different management practices, such as partial cutting,
- determining the role and function of small headwater streams in the context of the whole watershed,
- describing sediment budgets for all hydrological zones,
- assessing the historical rates of stream channel alteration and recovery in different parts of the province, with an understanding of the role of natural disturbance regimes, and
- identifying indicators of watershed "health" to evaluate and report on sustainable forest management.

THE FOREST SCIENCE PROGRAM IN 1999/00

The Forest Science Program comprises five core research activities, plus scientific and administrative support services. Three of the five research activities – Silviculture, Ecology, and Earth Sciences – are conducted by branch and regional staff with relative proportions that vary by location. Growth and Yield research is a branch activity. Forest Genetics also is primarily a branch activity, and includes tree breeding at the Cowichan Lake Research Station and Kalamalka Forestry Centre. Research support, including biometrics, communications and extension, is provided through the Victoria headquarters.

In addition to the specific research activities, researchers frequently become involved in a variety of special projects that span disciplines or fall outside the realm of traditional research. There is growing recognition that the principles of sound design, analysis and statistical inference are critical to the ministry's policy and decision-making processes, so the demand for researchers' knowledge in these areas is increasing. Also, researchers can be a source of very specialized knowledge and expertise for analyzing policy options and developing innovative solutions to contentious management issues.

Each of the research activities is summarized in the following section, followed by descriptions of some special projects to which researchers have contributed their knowledge and project management expertise.

SILVICULTURE

1. Silvicultural systems

Link to ministry priority or major initiative

Silvicultural systems research is conducted in support of the ministry's goals of ensuring stewardship of the forest and range resources and supporting forest-sector employment and community stability.

Background

Silvicultural systems researchers examine the consequences and implications of using alternative harvesting strategies. Interest in alternatives to conventional



A natural stand, estimated to be 130 years old, in which white spruce and aspen are co-dominants, near Fort Nelson.

clearcut harvesting is also driven by a growing appreciation of the ecological complexity of forests and of the non-timber values associated with them.

Summary

British Columbia's silvicultural systems research program, which includes approximately 20 multi-disciplinary projects throughout all of the forest regions, addresses a range of issues at both the stand and landscape levels. Program highlights for 1999/00 include the following:

- In the Roberts Creek study in the Vancouver Forest Region, trials of uniform shelterwood, strip shelterwood, and clearcut with reserves are included in a demonstration study block. In another study in the region, partial cutting and wildfire in coast-interior transition is being examined to determine whether alternative silvicultural systems may foster overstorey conditions that help retain biodiversity in managed Douglas-fir-dominated stands. In the Queen Charlotte Islands, single-tree and group selection methods are being tested in steep-sloped old-growth forests.
- At the Date Creek Silvicultural Systems Project in the Prince Rupert Forest Region, researchers are using SORTIE-BC, a partial-cutting, mixed-species, stand-development model calibrated especially for northern forests, to project the effects of harvesting patterns and regeneration regimes. In the multi-disciplinary project HyP3, researchers are studying a wide range of topics (e.g., regeneration, hydrology and soil ecology) with the objective of developing ecologically based guidelines to manage cedar-dominated forests.
- In the central and northern interior, University of Northern B.C. and ministry regional researchers are developing local silvicultural systems and partial-cutting methods appropriate for northern forest types. In the Cariboo region and the Rocky Mountains east of Prince George, they have established a number of multi-disciplinary, long-term trials to study different silvicultural system options, in both the wetbelt interior cedar-hemlock "rain forests" and the snowy, high-elevation spruce-balsam forests. In dry sub-boreal forests of the central interior plateau, the researchers are finding ways to minimize wind damage to reserve patches and Douglas-fir leave-trees after variable retention (i.e., partial-cut) harvesting. And in the extensive boreal forests of northeastern B.C., researchers are pioneering new methods, some of which include partial-cutting, for managing boreal, aspen-spruce mixedwood forests.
- In the Itcha-Ilgachuz Alternative Silviculture Systems Trial in the Cariboo Forest Region, group selection and irregular group shelterwood systems are designed to retain large areas of terrestrial and arboreal lichens, which sustain northern caribou herds. In a variety of study blocks, researchers are measuring lichens, regeneration, windthrow, micro-climate, and birds. In the Quesnel Highlands project, group selection is being tested to maintain mountain

caribou habitat. In another study, researchers are monitoring the use of shelterwood systems to foster Douglas-fir regeneration on frost-prone sites.

- In the Opax Mountain study in the Kamloops Forest Region, now in its seventh season, researchers are monitoring the response of interior Douglas-fir to small patch and individual tree selection.
- In the Nelson Forest Region, a study is underway on partial-cutting in root-disease-infected stands, in which researchers are monitoring factors such as seedling mortality and growth, litter decomposition, and understorey light conditions. In another study, researchers are examining the survival and growth of seedlings across a gradient of ambient light conditions.
- In a Research Branch study, researchers are using repeated measurement data for a wide variety of conifer and broadleaf species and stand management treatments to develop or refine silvicultural prescriptions. They are also using the data to calibrate or validate growth and yield models for a variety of stand and species conditions on the coast and in the interior.



A natural stand near Fort Nelson, showing white spruce under trembling aspen.

Results or products

For some projects, as much as 10 or more years of data have been collected, and research results are now beginning to influence forest management practices. For example, the Mountain Caribou Strategy under the Cariboo-Chilcotin Land-Use Plan endorses the use of group selection silvicultural systems to maintain caribou habitat.

Current study results are available at the regional and Research Branch websites (see "How to Contact Us" at the end of this report).

Cooperators

Silvicultural systems research has significant cooperative support from many individuals and groups, including forest companies, the B.C. Ministry of Environment, Lands and Parks, the Canadian Forest Service, research institutes including the Forest Engineering Research Institute of Canada (FERIC), and several North American and international universities.

2. Mixedwood management

Link to ministry priority or major initiative

Mixedwood management research is used by the ministry to refine its free-growing policy and



A site near Golden, B.C. shows light partial-cutting in a root-disease-infected stand in the Interior Cedar-Hemlock zone.

mixedwood stocking standards, which affect public and licensee forest management in the province. This research also provides information that the ministry needs to meet its objectives in managing mixedwood ecosystems for sustainable harvest, maximum yield, and biodiversity.

Background

Approximately 35% of B.C.'s operable land base is mixedwood forest. To manage this forest for sustainable harvest and various forest products, forest managers need to know what species combinations and densities will help meet their forest management objectives. Effectively managing this forest resource also requires models that can be tested and validated with mixedwood growth and yield data.

Stand-tending practices that are used for managing mixedwood ecosystems are being tested to enhance the basis for forest operations and decisions.

Mixedwood research for this essential support function has focused on aspen-spruce mixtures and paper birch-conifer mixtures in the Prince George Forest Region, pine-aspen mixtures in the Cariboo Forest Region, paper birch-conifer mixtures in the Kamloops Forest Region, and maple-conifer and red alder-conifer mixtures in the Vancouver Forest Region.

Summary

During 1999/00, among other work, mixedwood management researchers:

- measured the growth of pine-aspen mixtures in retrospective studies (near Williams Lake) and longer-term trials in the 100 Mile House, Horsefly, and Williams Lake districts. The data will provide valuable information on long-term growth and competition of mixedwood stands,
- summarized five-year results of white spruce seedlings growing under 40-to-80-year-old aspen canopies and in clearcuts. The trial compared tree growth and differences in micro-climate under both conditions,
- measured the height and diameter of conifers near Prince George and Williams Lake to quantify how the growth of understory conifers responds to birch overstoreys of differing densities,
- established a mixedwood species trial with red alder, paper birch, Douglas-fir, hemlock, and cedar in Maple Ridge (at the University of British Columbia Malcolm Knapp Research Forest). Growth of both conifers and broadleaves

will be measured over the next five to 10 years to provide key information for coastal free-growing guidelines, and

- established a young birch spacing trial near Enderby to assess how various birch spacings affect the growth of young lodgepole pine and larch. Growth of both conifers and broadleaves will be measured over the next five to 10 years to help revise interior free-growing guidelines.

Results or products

Information from these projects will be used to refine the ministry's free-growing policy in interior and coastal mixedwood stands, and to realize opportunities for sustainable harvest and maximum yield using multi-species management. Project results will provide valuable information for managing lands where crop-tree growth may be affected by broadleaf species and understorey vegetation, and will help forest managers develop alternative silvicultural systems for mixedwood stands. Finally, results will provide much-needed data to help researchers develop and validate mixedwood stand models and improve growth and yield predictions.

3. Stand management

Link to ministry priority or major initiative

The information from managed stand installations is used to support decisions and processes such as the Timber Supply Review and forest-level analysis for silviculture investment decisions for regional ministry clients.

Background

The stand management program was started in 1929 and has continued to expand, particularly since the early 1980s, when funding was provided by the Canada - B.C. Forest Resource Development Agreements (FRDA I and FRDA II). The current program consists of several hundred research installations with thousands of permanent sample plots. Field experiments are established by branch and regional researchers to quantify the response of trees and stands to various stand management treatments. Those include espacement (or plantation density), fertilization, pre-commercial and commercial thinning, pruning and partial cutting. Repeated measurement data, for a wide variety of conifer and broadleaf species and stand management treatments, are being used to develop or refine silvicultural prescriptions, and to calibrate or validate growth and yield models for a variety of stand and species conditions.

Summary

During 1999/00, the Research Branch and regions completed the scheduled remeasurement and maintenance of stand management experiments. The branch also established two trials. The first was a maximum productivity trial to document the effects of repeated, intensive fertilizing on

the growth and yield of interior spruce, and the long-term effects of repeated nutrient additions on various ecosystem processes. The second trial will document the effects of two different nitrogen sources on the growth response of lodgepole pine.

In the Prince George Forest Region, researchers examined the stand structure of natural wet montane forests over a time sequence of stand replacement after fire. Their objective was to develop criteria to assess the extent to which managed stands approximate the structural characteristics of natural stands.

Researchers in the Cariboo Forest Region launched a new demonstration study to address some of the problems of commercial thinning in interior Douglas-fir forests and monitor the effects of the thinning over time. Work continued on a trial for treatment of a 40-year-old repressed pine stand with three stand-tending treatments and six rehabilitation treatments, along with site preparation. Researchers also assessed 10-year-old site preparation trials with treatments such as mounding, screefing, and herbicide application.

Results or products

Data from these long-term studies are used to calibrate and validate the growth and yield models used in timber supply analyses, and for developing silvicultural prescriptions.

4. Forest insect and disease management

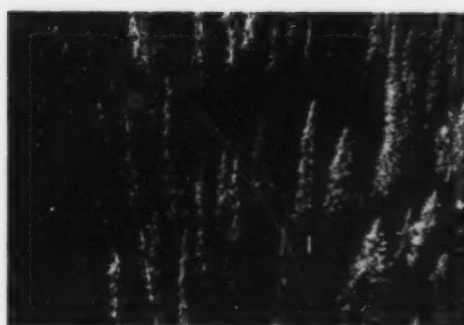
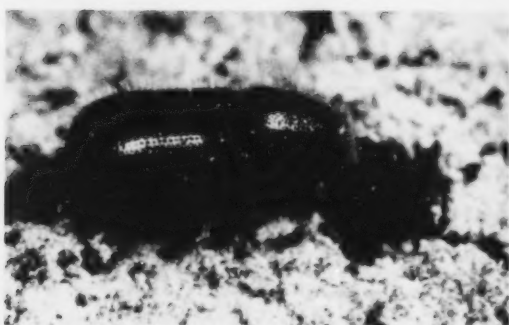
Link to ministry priority or major initiative

One of the Ministry of Forests' strategic goals, as identified in its performance planning, is to manage and conserve forest and grassland ecosystems for sustainable use now and in the future. To help achieve that goal, the Forest Science Program supports research in forest insect and disease management to protect or restore natural forest and grassland ecosystem productivity.

Background

Insects and disease are the cause of significant timber damage and loss in British Columbia each year. In 1998/99 alone, more than 2.5 million hectares were under attack by forest insects such as bark beetles, and defoliators like western and eastern spruce budworm and western hemlock looper. The costs are both short term (to fight infestation and disease, and in the commercial loss of timber), and long term (in loss of future volumes and regeneration stock).

During 1999/00, research was underway in the Prince George Forest Region to gauge the tree and growth losses from spruce budworm and to learn more about the biology of this poorly understood insect. Forest entomology research in the Kamloops Forest Region is developing hazard and risk rating systems to help forest managers in long-term planning and management.



(Left) A female western balsam bark beetle (*Dryocoetes confusus*). (Right) A stand of subalpine fir suffering from attack by the western balsam bark beetle.

These systems, or models, can help predict when and where an insect outbreak may occur. Research is also in progress to determine the effects of insects on young lodgepole pine-dominated stands in several biogeoclimatic zones.

In disease research, studies of *Armillaria* root disease and saprophytic fungi (i.e., those that live on dead or decayed organic matter) are underway in the Cariboo and Nelson forest regions. Researchers hope to determine whether a competitive fungus inoculated into stumps after timber harvesting has the potential to mitigate losses caused by *Armillaria* root disease, and if strategies to manage the populations of saprophytic fungi following timber harvesting can mitigate the losses from *Armillaria* root disease.

Summary

Collaborative projects with the Canadian Forest Service on two-year-cycle budworm and eastern spruce budworm are ongoing to assess tree mortality and growth loss, and to better understand the biology of both insects.

In response to rust problems and maximum-density spacing issues in the Prince George Forest Region, researchers developed a regional guideline that provides flexibility in spacing criteria under certain levels of rust.

In the Kamloops Forest Region in 1999/00, among other work, researchers:

- compiled and analyzed the history of defoliation by western spruce budworm, which will be coupled with data on stand structure and defoliator effects to create a susceptibility rating system for the insect,
- launched a mass trapping and anti-aggregant system to control the Douglas-fir beetle, which marks the first time that mass trapping for this insect has been attempted in B.C. on an operational level,

- added root removal as a third treatment to trial blocks already testing two treatments (i.e., harvesting and then inoculating with competitive fungus, and not inoculating) for *Armillaria* biocontrol, and began checking seedling mortality on blocks treated by root removal techniques,
- continued work on 29 trials on various aspects of maintaining ecosystem complexity (e.g., woody debris management, stump-top cutting to promote decay, and in-block branch and debris piling) as a means of mitigating losses from *Armillaria* root disease, and
- assessed mortality rates on five installations where stumps had been inoculated against *Armillaria* with competing fungus. (Although in most circumstances the inoculated competitive fungus occupies most of the surface volume of inoculated stumps after two years, there is insufficient mortality to date to determine if the inoculation treatment is having an effect on reducing the incidence of root disease.)

Results or products

Forest insect and disease management research results help identify areas of future salvage. The work also leads to more accurate estimates of timber that is killed or damaged but cannot be harvested, for the Timber Supply Review.

5. Light models

Link to ministry priority or major initiative

Light models help researchers design silviculture prescriptions and test the effects of stand structures on forest growth dynamics in complex stands (e.g., existing uneven-aged, mixedwood and mixed-species stands, and those created in variable retention silviculture systems).

Background

Some of the unknowns limiting our ability to model complex stand development are the rates at which understorey trees establish, grow, die, or become crop trees, and the effect of different types of harvesting patterns on the growth of residual trees. Competition for light is one important determinant of these dynamics. A stand light model predicts relative light conditions within and under the canopy, based on the positions and sizes of trees in a forest stand, thereby indicating the degree to which individual trees may be shaded.

Research Branch is currently working with two computer light models. *tRAYci* is being integrated with the Tree and Stand Simulator (TASS) growth and yield model to expand its applicability to complex stands. The Light Interception and Transmission Estimator (LITE) is suitable for a broad range of research and silviculture applications when quantifying light penetration through the canopy is of interest (e.g., in underplanting). Researchers in the Prince Rupert Forest Region have calibrated another simple light model in SORTIE-BC.

Summary

These light models are improving the way in which researchers simulate forest dynamics. They allow researchers to model prescriptions that retain complex stand structures over time and space, including the influence of retained canopy trees on recruitment, growth and mortality of subcanopy trees. The tRAYci model has been used to predict light values within young, even-aged stands of coastal Douglas-fir. Calibration for uneven-aged interior Douglas-fir and southern interior cedar-hemlock stand types is underway. The most recent version of LITE includes the effects of understorey vegetation, and work has begun on a dynamic model (BRITE), which will predict how growing-season transmittance changes with stand age. The light model in SORTIE-BC has been thoroughly tested: it can accurately predict spatial variation in understorey light levels of the complex mixed-species forests of northwestern B.C.

Results or products

During 1999/00, researchers published several sets of results, including:

- a study of the relationship between crown light absorption, as predicted by tRAYci, and tree bole volume growth,
- an extension note, based on the information gained through the development of the LITE model, on measuring light in the forest, and
- two journal papers from the work on the light model in SORTIE-BC.

Cooperators

The Danish Forest and Landscape Research Institute, the B.C. Ministry of Environment, Lands and Parks, the University of Alberta, and the Institute of Ecosystem Studies, New York.



Hemispherical photo showing illumination experienced by an understory tree about 1.3 metres in height.

GROWTH AND YIELD

1. Development of growth and yield models

Link to ministry priority or major initiative

Growth and yield estimates are integral to silviculture planning and the timber supply analyses used in the Timber Supply Review.

Background

The development of growth and yield models in North America began in the early 1960s when computing technology advanced enough to allow rapid calculations. Researchers developed several types of model structures, from simple regression-based stand-level systems that projected whole stands, to more complex individual-tree models. Individual-tree models may consist of tree lists that do not recognize the spatial distribution of trees, or they may be spatially explicit (i.e., they record the ground location of each tree).

The Tree and Stand Simulator (TASS) was conceived and developed by Dr. Ken Mitchell in the mid-1960s when he was a graduate student at Yale University. TASS is a distance-dependent model that simulates the interactions of tree crowns in a three-dimensional computer space. It also evaluates various management activities, such as plantation spacing, thinning, pruning and fertilizing.

Like many models of its day, TASS was originally developed because there were very little long-term field data available to assess the impacts of intensive silviculture on growth and yield of managed second-generation forests in B.C. In addition, management activities change much more rapidly than field plots are established and remeasured. The intention of TASS was therefore to extend existing data and bridge knowledge gaps for treatment combinations that were infrequent in the available database.

Researchers in the Prince Rupert Forest Region are developing new modelling tools for growth and yield projections of complex, structured mixed-species stands following natural disturbance or partial-cutting prescriptions. The focus of the current research is on developing spatial indices to predict individual canopy tree growth and mortality rates as a function of immediate tree neighbourhoods. This work will help forest managers assess the long-term sustainability and growth and yield implications of retaining complex stand structures through alternative cutting practices.

Summary

Each model arises from a specific need, set of stand and species conditions, and modelling perspective. For example, PrognosisBC arose from the need to model very complex stands in the southern interior of B.C., where stands contain as many as 11 coniferous species and have irregular cutting histories and a plethora of insect infestations. The lack of unbiased, long-term

permanent plot data drove the development of a growth model that is not spatially explicit. It is based on inventory data, diameter growth measurements, and other data.

TASS was created for specific research purposes, but model development often takes unexpected directions. Because the biological fidelity of the system allows users to simulate a variety of activities, requests for new applications have helped researchers further develop the model (see the section following on variable retention harvesting).

SORTIE was added to the group of models to help researchers better understand tree dynamics after single or repeated small- to intermediate-scale disturbances in forest stands. SORTIE allows researchers to simulate multiple tree species with vastly different life histories and growth habits.

Results or products

Growth and yield models provide information that helps forest managers make knowledgeable resource-use decisions for long-term sustainability and investment effectiveness.

2. Simulation of variable retention harvesting

Link to ministry priority or major initiative

Growth and yield estimates for all forest types, management activities, and harvesting strategies are required for silviculture planning and timber supply analyses.

Background

Faced with ongoing national and international pressures to reduce clearcutting in favour of variable retention methods (i.e., retaining a portion of the original stand to preserve biodiversity, wildlife habitat, and other values), forest companies are changing their harvesting strategies. In 1998, Macmillan Bloedel Ltd. (now Weyerhaeuser Canada Ltd.) was the first forest company in British Columbia to announce a shift to variable retention. Since then, several other companies and the ministry's Small Business Forest Enterprise Program have announced similar plans or are evaluating whether or not to increase the use of variable retention harvesting.

Summary

A joint government-industry committee was formed to evaluate the consequences of the MacMillan Bloedel decision, and the then-current version of TASS was adapted to estimate the effects of variable retention on the predicted volume of young stands planted among trees retained in grouped or more dispersed patterns. TASS was programmed to compare the yields of stands that had been regenerated using 10% overstorey retention levels, to those obtained in clearcuts, where yields were 100%. TASS predicted that yields would decrease to 86% with highly clustered patterns of retention, and to 70% using highly dispersed patterns. Further work is underway to refine these preliminary estimates.



*Group retention harvesting on
Weyerhaeuser Canada Ltd. property.*



*A Tree and Stand Simulator (TASS) representation
of group retention harvesting on the same site.*

Results or products

Weyerhaeuser Canada Ltd. has begun to implement variable retention in the field, guided by TASS predictions and other information. The company is establishing primarily grouped and clumped patterns (e.g., group retention and strip shelterwood), rather than dispersed patterns such as uniform shelterwood, or combinations of grouped and dispersed. The greater growth and yield of trees regenerated in grouped variable retention patterns will result in more favourable timber supply projections.

Cooperators

Weyerhaeuser Canada Ltd.

ECOLOGY

Ministry of Forests ecology research is carried out in:

- Ecosystem classification (Biogeoclimatic Ecosystem Classification)
- Old growth
- Coarse woody debris
- Landscape ecology
- Wildlife
- Range management
- Non-timber forest products

1. Ecosystem classification

Link to ministry priority or major initiative

B.C.'s Biogeoclimatic Ecosystem Classification (BEC) system is integral to many Forest Practices Code guidebooks and to timber supply analyses.

Background

The BEC provides a classification framework of ecosystems, from broad to specific levels of categorization. The broad biogeoclimatic (or zonal) units have been applied to land management and protected-area planning, seed zones, forest insect risk, natural disturbance types, and wildlife habitat management. It also provides the essential framework for

forest ecosystem management, silviculture decision-making, and integrated resource management.

The more detailed ecosystem classifications (i.e., BEC subzones, variants and site series) provide a structure for presenting management interpretations. A range of management guidelines and interpretations is usually presented for each site series, and may include:

- the most suitable tree species for regeneration,
- stocking, stock type, and "free-to-grow" standards for tree species,
- vegetation competition after harvesting,
- forest harvesting season,
- site-limiting factors and reforestation considerations, and
- a site index by tree species.

Summary

Large-scale biogeoclimatic mapping was completed during 1999/00 for portions of the Prince George, Nelson, and Prince Rupert forest regions, and the field guide for the northwest portion of the Prince George Forest Region was updated. Researchers also completed wetlands classifications for interior and north coast estuaries, a wetlands sampling manual, a wetlands extension note, and draft lists of rare wetland and aquatic plants.

Field sampling was carried out to provide updated or new classifications in drier climatic regions of the Kamloops Forest Region, the Cariboo grasslands, high-elevation areas, and wetlands. Species selection guidelines were updated for a new set of regional establishment to free-growing guidebooks. Provincial Resource Inventory Committee standards for predictive ecosystem mapping were completed, and a model for predictive ecosystem mapping (EcoGen) was released. An electronic extension note on technical issues within predictive ecosystem mapping is available on the Research Branch website.

During 1999/00, researchers also reviewed and revised the list of rare plant associations in B.C. (i.e., Red- and Blue-listed ecosystems as defined by the B.C. Ministry of Environment, Lands and Parks).

Results or products

These activities provided new or updated ecosystem-based tools for forest management planning, analyses and decision-making, which will be applied in various ministry operations, from broad to site-specific scales. Specifically, activities of the past year will help forest managers and foresters apply the guidelines in several Forest Practices Code guidebooks, including *Landscape Unit Planning*, *Managing Identified Wildlife*, and *Establishment to Free Growing*. The predictive ecosystem mapping model has the potential to provide inexpensive, large-scale

ecological mapping for the entire province, which will have a variety of uses, including site productivity assessments for timber supply analyses. The use of predictive ecosystem mapping rather than the more labour-intensive terrestrial ecosystem mapping would be substantially less expensive and enable the entire province to be covered more rapidly.

Cooperators

The B.C. Ministry of Environment, Lands and Parks.

2. Old growth

Link to ministry priority or major initiative

Old-growth forest research is important because old growth helps maintain B.C.'s biodiversity, forms part of a recognized global resource base, and has economic value, especially on the coast. It also helps the ministry meet its domestic and international sustainability objectives.

Background

Forest resource managers need to be able to identify old-growth forest attributes so that they can develop silvicultural treatments which will maintain or create them earlier in the growth cycle. Managers also need to characterize and locate rare and threatened old-growth forest ecosystems to meet Forest Practices Code requirements for maintaining biodiversity.

Summary

A number of sites thought to have old Douglas-fir stands were examined in the Squamish Forest District during 1999/00. A stand found in the upper Elaho River valley includes trees estimated to be more than 1,000 years old, which makes them some of the oldest living Douglas-fir trees known in the world. Several research projects, primarily in the cedar-western hemlock and interior cedar-hemlock zones, are examining old-growth structure, dynamics, and "old-growth-dependent" species such as lichens, mosses and liverworts.

Results or products

Progress was made this year on the identification of old-growth forest attributes, and a preliminary list of rare and threatened old-growth forest ecosystems has been created.

3. Coarse woody debris

Link to ministry priority or major initiative

Stewardship of the forest and range resources is central to the Ministry of Forests' mandate. Essential to that stewardship role, and to ensuring biodiversity, is understanding the role that coarse woody debris (i.e., large, dead and down woody material on the forest floor) plays in forest ecosystem dynamics.

The Forest Practices Code addresses coarse woody debris management, which must accommodate both timber utilization standards and the provincial government's Small Scale Salvage Initiative, as well as ecological considerations.

Background

Biodiversity and long-term site productivity on uplands and in riparian zones are important considerations in forest management in B.C. To provide for and maintain those, forest managers need to balance operational considerations, such as harvesting methods and post-harvest salvage of remaining usable wood, with maintenance of some coarse woody debris for ecological purposes.

Summary

A short-term provincial strategy for managing coarse woody debris was announced in 2000 to clarify policies, legal requirements, and other considerations. The strategy currently consists of:

- a clarification of the present policy and legal requirement for coarse woody debris management,
- an education component, guiding principles and management considerations that will increase the likelihood of maintaining coarse woody debris values at no extra cost and with no adverse effects on the timber supply, and
- a commitment to assess the effect of present forestry practices and policy on coarse woody debris management over the next three years.

The Coarse Woody Debris Provincial Technical Working Group, which includes Forest Science Program representatives from the Research Branch and all forest regions, was established to identify problem areas, assess coarse woody debris management options, and launch pilot projects to determine the operational implications of different management approaches. The working group will revise or replace the short-term provincial strategy by May 1, 2003.

Results or products

An intensive research project is underway in the Vancouver Forest Region, in cooperation with industry and other researchers, and another is planned for the Prince Rupert Forest Region. More extensive pilot projects to measure coarse woody debris loadings and assess the implications of different coarse woody debris management approaches on harvesting operations are planned for most of the other forest regions.



Dead wood, in the form of coarse woody debris on the ground and in standing dead trees, performs vital ecological functions, providing habitat for a variety of organisms and contributing to long-term forest-site productivity. (Shown: A site in the south Cariboo Forest Region, west of 70 Mile House.)

Cooperators

The B.C. Ministry of Environment, Lands and Parks; Weyerhaeuser Canada Ltd. (B.C. Coastal Group), and the Forest Engineering Research Institute of Canada (FERIC).

4. Landscape ecology

Link to ministry priority or major initiative

Landscape ecology research provides background and input for landscape-unit planning, timber supply analysis, and wildlife habitat supply modelling.

Background

Several Forest Practices Code guidebooks relate to landscape-level planning, but the modelling approaches needed to implement some of those guidelines are varied and still undergoing refinements. In general, as all types of forest planning become more spatially explicit, the demand for new tools and information increases.

Summary

Projects throughout the province are investigating the influence of natural disturbance regimes on timber supply and non-timber forest values. Examples include:

- Research is being done in the Prince George Forest Region into the multi-scale influence of wildfire on habitat.
- In the Columbin Forest District, researchers are simulation-modelling caribou habitat changes due to forest harvesting.
- A project to predict old-growth biodiversity at the landscape level, using cyano-lichens as indicators, is underway in the Kamloops Forest Region.

Results or products

This area of ecology research provides a better understanding of the influence of management activities on landscape-level patterns and processes, and, in turn, how spatially and temporally stochastic (or random) processes at the landscape level affect forest management activities.

Cooperators

The Robson Valley Enhanced Forest Management Pilot Project, and the Canadian Forest Service.

5. Wildlife

Link to ministry priority or major initiative

Maintaining wildlife habitat is an important responsibility of the Ministry of Forests. Forest management activities affect British Columbia's landscape across the entire province. Research

helps inform these activities so that they can be undertaken in ways that enhance or maintain habitat for some wildlife species.

Background

Because British Columbia's forests are managed for a diversity of values, resource-use conflicts are not uncommon. Resource managers therefore need scientifically reliable information on forest ecosystems, and on how to maintain biodiversity and integrate multiple resource values, so they can make informed management decisions and develop appropriate management prescriptions.

Summary

Wildlife habitat researchers provide information and advice to the ministry's Operations Division on silvicultural systems, wildlife tree retention, post-harvesting silviculture prescriptions, and other management practices to maintain wildlife habitat and biodiversity. They also develop models and identify habitat requirements to integrate the needs of high-profile species – such as grizzly bear and caribou – into forest management plans and timber supply models.

During 1999/00, research included studies on grizzly bear habitat selection, the effects of highways, roads and railroads on bear habitat, and the effects of various partial-cutting systems on caribou. Other studies focused on deer habitat, riparian habitat use by birds, and habitat relationships of forest songbirds.

Results or products

Wildlife habitat researchers contributed information to Land and Resource Management Plans, landscape-unit plans, and Forest Development Plans. They also assisted in developing recovery plans for species at risk.

Cooperators

Parks Canada, the Canadian Wildlife Service, the B.C. Ministry of Environment, Lands and Parks (animal research), universities, consultants, and industry.

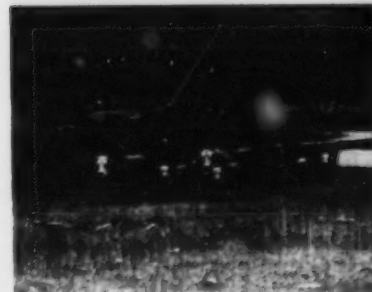
6. Range management

Link to ministry priority or major initiative

Range research helps the ministry meet its range management obligations to conserve grassland and open forest ecosystems, produce forage for domestic livestock and wildlife, and manage livestock grazing tenures.

Background

Range research includes analyses of livestock management in riparian ecosystems. Range research also includes analyses of the best practices to



Riparian areas are being monitored near 100 Mile House to determine the extent and rate of recovery following improved livestock management.

restore ecosystems where fire suppression activities have excluded fire from "fire-adapted" ecosystems. Owing to fewer fires, these ecosystems can become overgrown with dense thickets of spindly trees that often fuel abnormally destructive wildfires. These less frequent but very hot fires do more damage than more frequent, naturally occurring fires. Fire suppression can, therefore, create ecosystems that are considered to be "degraded." Restoration activities are required to bring these ecosystems back to approximately natural conditions.

Riparian vegetation is important for stabilizing stream banks, regulating water temperature, and protecting water quality. Riparian areas also provide watering and grazing sites for livestock. However, excessive grazing, browsing and trampling by livestock can alter riparian areas to the point where they can no longer provide the necessary forage, water resources, and wildlife habitat.

Dry forests in the Invermere Forest District have been significantly altered by fire suppression, selective logging, Christmas tree production, and grazing. These activities have altered the landscape to the point that wildlife habitat for certain species has diminished, forage production for domestic livestock and wild ungulates (i.e., hooved animals) has been reduced, timber quality is reduced, insect and disease infestations have escalated, and the risk of wildfire has increased. These effects on natural resource values were recognized in the regional land-use planning process (i.e., the Kootenay-Boundary Land-Use Plan) and led to the creation of Forest Renewal BC's Terrestrial Ecosystem Restoration program.

Summary

A project was established near 100 Mile House to examine alternative livestock management options in grassland communities and riparian areas associated with lakes and ponds. The Livestock Grazing in Riparian Areas Adaptive Management Project is designed to help resource managers maintain or restore the natural function of the riparian areas, as required by the Forest Practices Code. Problem analyses on the effects of range practices on waterborne disease and livestock/riparian management were also completed. An adaptive management project in the East Kootenay trench is monitoring the efficacy of ecosystem restoration activities. During 1999/00, two ecosystem restoration blocks were sampled and treated near Invermere in the Nelson Forest Region.

Results or products

In their preliminary recommendations, researchers working on the adaptive management ecosystem project in the East Kootenay trench have already identified the stands with the best potential for meeting district restoration objectives. Range research has also generated information that will help managers identify research needs and future policy on livestock and waterborne diseases and livestock management in riparian areas. During 1999/00, results on

range management issues were widely disseminated to the forest management and research communities through reports, journal papers, and posters.

7. Non-timber forest products

Link to ministry priority or major initiative

One of the Ministry of Forests' strategic priorities is to practise planned, integrated resource management and use. Improving the knowledge base for non-timber forest values and products supports that objective. Non-timber forest products are especially important at local levels because they contribute to local employment and local economies. Non-timber values are a key feature of most forest management certification processes.

Background

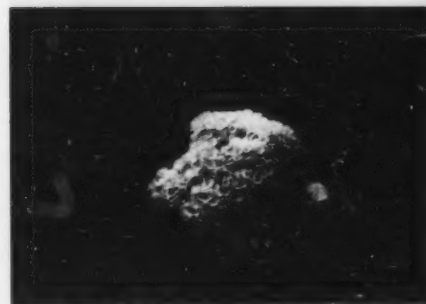
As researchers better understand the ecology of important non-timber forest products, forest managers will become better equipped to manage them effectively with other values. Resource-use planners will also be able to integrate the information into land-use planning, silvicultural systems, and stand-tending procedures.

Summary

During 1999/00, research projects included studies of the preferred habitat for pine mushroom and chanterelle production, assessments of salal harvesting techniques and site productivity for salal, the impacts of silviculture systems on mushroom productivity, and the economics of non-timber forest products industries in general. Research was also conducted into the commercial production of edible mushrooms on cutblocks and in forest stands, through inoculation and specific stand-tending. The effects of fire and natural disturbances were described for numerous plant species having botanical forest product potential in southeastern B.C.

Results or products

Due in part to new research information, there is a growing awareness of and interest in the ecological and economic importance of species that are valuable to non-timber forest production in B.C. forests. Several forest districts are supporting the collection of information on habitat preferences and distribution of pine mushrooms, and integrating this new information into management plans. Some are also testing different silvicultural systems. Other research has identified, by ecosystem, plant response groups that would be adversely affected by reduced fire frequency.



Cauliflower mushroom (Sparassis crispa).



This sub-boreal spruce installation at Topley, in the Prince Rupert Forest Region, received a treatment consisting of whole-tree harvesting and removal of the forest floor, with moderate soil compaction.

This photo was taken one year after treatment application.

Cooperators

- the B.C. Ministry of Agriculture, Food and Fisheries
- Okanagan University College, Biology Department
- University of Victoria, Environmental Studies
- University of British Columbia, Forest Resources Management and Department of Botany
- Mycological Resources
- Symbios Research and Restoration
- Mitchell and Associates

EARTH SCIENCES

1. Watershed management

Watershed management and the hydrologic cycle are covered in depth in the feature article in this report, "Integration of Forestry and Watershed Processes" (see page 11).

2. Soil conservation

Link to ministry priority or major initiative

The work of the soil science program supports key ministry priorities related to the Forest Practices Code, the costs of harvesting, the allowable annual cut, soil conservation and rehabilitation, and the demonstration of sustainable forest management. The Long-Term Soil Productivity Study contributes to ministry priorities by providing rotation-length information on the effects of soil compaction and organic matter loss on site productivity.

Background

The primary goal of Ministry of Forests soil science research and extension is to help maintain soil productivity by providing cost-effective management tools and information.

Timber harvesting, road-building, site preparation, and other forest management activities affect the physical, chemical and biological properties of soil. This can lead to significant changes in site productivity. Researchers have helped develop strategies to minimize such damage and to conserve soils during forest management activities. The effect of soil disturbance on site productivity and off-site

values (e.g., from erosion or instability) can be positive, negative, or neutral (i.e., no effect). Researchers, working with operational and industry staff, have contributed to the development of strategies to maximize the positive effects while minimizing potential negative effects on soil during forest management activities. The Long-Term Soil Productivity Study, which was designed on rotation-length time frames, will help the ministry minimize the future negative effects of management practices.

Summary

During 1999/00, regional and branch soil scientists continued work on a network of research and demonstration sites throughout B.C., extrapolating the results to a broad range of soil conditions. Study topics included soil rehabilitation, the effects of silviculture systems and root removal on soil productivity, nitrogen fixation and cycling, the effects of prescribed burning on soil and forest productivity, and ectomycorrhizal mushrooms and mycorrhizal associations in crop trees.

Highlights included integrated studies on forest management of calcareous (or high pH) soils, development and extension of cost-effective harvesting strategies to protect soils while still reducing costs, and new, experimental work on the use of competing fungi to help control *Armillaria* root disease.

In the Long-Term Soil Productivity Study, the sub-boreal spruce sites have now all passed Year 5 and the required set of data for Year 5 has been collected. Reports, publications and other extension activities are in progress. The boreal white and black spruce sites are all now installed, and are being monitored and maintained. Research activities are underway on interior Douglas-fir sites in the Kamloops and Nelson forest regions.

Results or products

Research results have improved the technical foundation for soil components of the Forest Practices Code and contributed to management practices that demonstrate sustainable development. Research information about soil productivity has also been used in numerous Timber Supply Reviews.

During 1999/00, extension activities of the Long-Term Soil Productivity Study included field tours and publications. Results of this research have been used by Fort Nelson Forest District staff and licensees to determine the window of operability on fine-textured soils supporting aspen.

Cooperators (Soil conservation)

- the Canadian Forest Service
- the University of British Columbia
- the University of Northern British Columbia
- Okanagan University College
- the Forest Engineering Research Institute of Canada (FERIC)

- other academic and government agencies
- Lignum Innovative Forest Practices Agreement (IFPA)
- Tembec Industries Ltd.
- Slocan Forest Products Ltd.
- Pope & Talbot Ltd.
- Forest Renewal BC

Cooperators (Long-Term Soil Productivity Study)

- the Canadian Forest Service (Pacific Forestry Centre)
- Crestbrook Forest Industries Ltd.
- the University of British Columbia
- BC Research Inc.
- U.S. Department of Agriculture, Forest Service

3. Terrain stability

Link to ministry priority or major initiative

Identification of areas with potentially unstable terrain is a requirement under the Forest Practices Code in B.C. Terrain stability is also an important consideration in the Timber Supply Review process, because unstable terrain can be difficult or impossible to log without destabilizing the slopes.

Background

The frequency of landslides can increase significantly following timber harvesting or road-building on unstable terrain. To prevent soil loss, minimize damage to streams and fish habitat, and protect forest road infrastructure, forest managers need to be able to accurately identify sensitive sites where stability might affect management activities.

Summary

A study relating landslide occurrence to terrain attributes and forest development is now in its fifth year in the Nelson and Vancouver forest regions. More than 1 million hectares and some 2,000 landslides in the Nelson Forest Region have been inventoried. In the Vancouver Forest Region, data have been collected on more than 3,000 landslides.

During 1999/00, researchers completed a statistical analysis for predicting gully instability on Vancouver Island. Other work included a study established in the Prince George Forest Region for fire-generated mass movement, and a cost and reliability comparison of conventional Terrain Stability Mapping with computer-generated stability maps built on very detailed digital topographic models.

Results or products

By collecting information on landslide frequencies and causes, researchers will be able to improve the reliability of Terrain Stability Mapping. Predictive matrices from the Vancouver Island gully study have now been incorporated into the Forest Practices Code Gully Assessment Procedure.

Cooperators

Utah State University.

4. Forest climatology

Link to ministry priority or major initiative

Forest climatology research information contributes to our understanding of seedling survival in cutblocks, snow accumulation and melt in watersheds, and, on a global scale, of processes that link land resources to the earth's climate.

Background

Climate is an important factor that controls forest regeneration and growth, as well as natural disturbances such as fire and windthrow. Forest organisms have specific microclimatic requirements for optimum growth, so forest managers need to understand how forestry activities affect the micro-climate.

The province has developed a strategy for the management of greenhouse gases – the *British Columbia Climate Change Business Plan, 2000/03*, coordinated by the B.C. Ministry of Environment, Lands and Parks – that requires various sectors of the economy to develop greenhouse gas management plans. Determining how forest management affects B.C.'s forest carbon balances is an important part of this work.

Forest management influences the hydrologic cycle by altering the amount of precipitation that reaches the forest floor and the amount of water that is lost through evapotranspiration. The information that researchers gain from evaluating these changes helps minimize the risk of adverse impacts on streams.

Summary

Silvicultural systems research during 1999/00 included assessing the micro-climate across boundaries between the standing forest and cutblock openings (i.e., the size of the edge effect) at the Sicamous Creek Research Project. In this study, edge effects on micro-climate extend less than one tree height on either side of the boundary.

In research into global warming and forests, more work is needed to improve knowledge about the sensitivity of species and ecosystems to climate, to continue



Part of a rainfall-interception system.

provenance trials in different climatic regimes, and to develop adaptive management strategies. In carbon-balance research, a preliminary assessment of the current and future carbon balance of B.C.'s forests has been made. It indicates the potential for the forest to be a significant sink of carbon. Management strategies to maintain this sink and provide benefits for the sale of carbon credits are being determined.

In forest hydrology during 1999/00 at the Upper Penticton Creek Watershed Experiment in the interior, and at the Carnation Creek Watershed Study on the coast, researchers evaluated the effect of forest canopies on the water balance of the root zone, and on the water draining into streams. The removal of forest canopies was found to significantly affect the water balance by changing the interception of precipitation.

Results or products

A management decision framework has been developed to guide forest management strategies that will help minimize impacts of climate change on forests. Preliminary analyses of selected species and ecosystems suggest that existing forest management tools can be modified to address the potential impacts of climate change. For example, if climate changes are predicted to affect timber supply, forest managers may decide to harvest trees later in the rotation, or to accept smaller-diameter logs. If the climate is drier, then reforestation plans might prescribe more drought-tolerant species or stock types.

Cooperators

The University of British Columbia.

FOREST GENETICS

Links to ministry priority or major initiative

All of the research areas under Forest Genetics contribute to delivering tree improvement benefits, which is a stated 1999/00 priority for the Forestry Division of the ministry.



Western hemlock shoots grown at (from left to right) 0, 4, 8 and 12 kilojoules of ultraviolet-B radiation per square metre per day.

Ozone depletion: seedling responses to UV-B radiation

An important component of global climate change is ozone depletion in the stratosphere, which allows increased ultraviolet-B (UV-B) radiation to reach the surface of the earth. Researchers predict that UV-B levels will increase in British Columbia over the next few decades, with potentially harmful consequences to forest ecosystem health. High-energy UV-B wavelengths damage plants by altering DNA, destroying proteins, bleaching pigments and decreasing photosynthesis and growth. In 1996, Forest Renewal BC funded a four-year project to estimate the risks of increased UV-B for tree species native to B.C. The Forest Practices Code also requires forest planners to assess forest health risks, including abiotic

(or non-living) factors, when developing silvicultural plans and prescriptions.

Researchers tested seedlings of several species and seed sources in greenhouse UV-B chambers in Victoria. Responses varied with increasing UV-B, from stunted and disfigured growth, to few visible changes. UV-B exposure had more effect on low- than high-elevation seed sources. Most species showed increased heat tolerance after growing under high UV-B, some exhibited increased frost hardiness, and some underwent changes in chlorophyll and UV-B-absorbing pigment content.

The variety of responses among and within species will help researchers and forest managers develop solutions to deal with future increases in UV-B levels and help minimize the risk of UV-B damage to forest productivity.

Project information was released to users in B.C., North America, and overseas. Better information about the problems associated with higher levels of UV-B and information on species sensitivity can be used in seedling nursery and planting management, and the B.C. testing methods have opened the door for new studies of the effects of UV-B in forestry and agriculture.

1. Improving the western larch seed supply

Background

Western larch is a fast-growing, shade-intolerant, pioneer species that thrives on low-to-mid-elevation sites in southeastern British Columbia. Throughout its natural range, western larch is important for its timber, outstanding aesthetics and important ecological values, such as watershed protection and wildlife habitat. Like most species of *Larix*, western larch flower crops are sporadic, infrequent and expensive to collect.

Summary

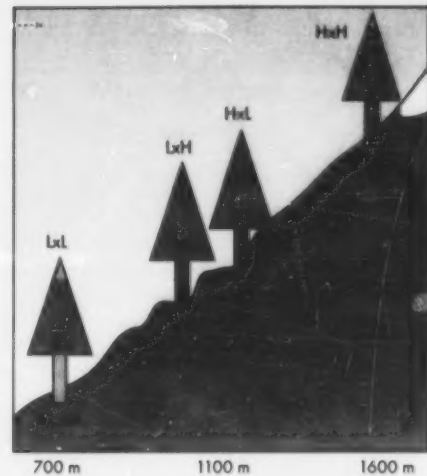
In 1986, the Ministry of Forests and industrial foresters foresaw an increasing demand for improved western larch planting stock, and a scarcity of seed supply. They therefore requested that the ministry immediately implement a tree improvement program to provide a constant supply of select seeds for reforestation. Project work began in spring 1987.

Initially, two breeding zones – East Kootenay and West Kootenay/Shuswap Adams – were identified, based on biogeoclimatic information and administration boundaries. Since 1987, more than 610 western larch parent trees have been selected in wild stands in both zones. Branches for grafts and open-pollinated seeds were collected from each tree for clone bank establishment and progeny testing. To evaluate each parent tree's genetic worth, or breeding value, seedling families were established to evaluate long-term field performance. Four series of progeny tests were established on 17 sites, the oldest of which is now 10 years old. In 1989, two soil-based grafted seed orchards were established at Vernon to provide select seeds for planting in the two zones. Seed production began in 1997 and, to



Harvesting select western larch seeds in Vernon, B.C.

Lodgepole pine seedling height and fall frost damage for progeny of crosses between different elevations. The percent damage after freezing to the same level (blue colour) is shown inside each tree. The average elevation of the parents is shown at the bottom of the graph.



date, seed orchard staff have collected more than 27.8 million seeds. Operational planting of select seedlings from these first seed crops began in spring 2000. Removing rogues from seed orchards and replacement grafting to improve the orchard's genetic quality are ongoing, based on the latest progeny test information.

Results or products

The ministry expects that, within two years, more than 80% of select western larch planting stock in B.C. will originate from seed orchards.

2. Realized gain trials

Background

Genetic gain estimates are estimates of increased tree volume achieved at rotation age from trees with genetically superior growth rates. These estimates are an integral part of growth and yield models that are used to determine the allowable annual cut. Original estimates of genetic gain have been based on measurements of seedling performance from family genetic tests in the field. The problem with making inferences directly from these experiments is that seedlings from superior families out-compete slower-growing neighbouring seedlings, creating a bias as the genetic trials mature. Realized gain trials are specifically designed to verify genetic gain in an environment in which such competition is not a factor.

Summary

Realized gain tests are long-term studies designed to continue for 10 years or more. Tests incorporating four planting densities have been established for Douglas-fir at six sites. Four similar planting densities were used for western hemlock. These trials were replicated at six locations along the coast of B.C. Early results indicate that the predicted potential gains are realized even when trees are growing in competition with other fast-growing trees. The implications are that researchers can rely on test data gathered in previous progeny tests, and on the theory that genetic gain can be estimated through progeny testing and selection.

Results or products

Genetic gain estimates are now incorporated into TIPS (Table Interpolation Program for Stand Yield), a model that is used for timber supply analysis and allowable annual cut determinations. Incorporating genetic gain estimates means that companies which regenerate harvested lands with genetically improved seeds may earn immediate credits for increasing their current allowable annual cut.

3. Orchard seed deployment

Background

There are several ways to evaluate the quality of seed orchard material. One is to look at adaptive traits to determine if trees produced from orchard seeds are "suitable for use" - whether they have desired traits such as frost and drought resistance, or resistance to insects.

The traits of inter-crossed progeny can vary considerably in growth and adaptability, because selected parent trees in B.C. seed orchards, as well as in selected seedlots from wild stands, are derived from a range of environments and elevations. Approximately 8 million seedlings are needed to meet planting requirements in the south of the province, so the potential impact on plantation performance is significant.

Summary

Researchers studying lodgepole pine seedlings from 16 crosses between parents from low and high elevations found clear patterns in growth and physiological responses to drought, heat and frost. In the second year of growth, seedlings from low-by-low (LL) crosses were 13% taller and less than half as frost-hardy as those from high-by-high (HH) crosses. Surprisingly, HH seedlings had the highest rates of photosynthesis before and during summer drought. However, seedlings that were drought-stressed were more damaged by heat and less frost-hardy in mid-autumn.

Results or products

Tree breeders are using these results to consider the movement of seeds across elevational bands and to select particular parents and crosses to better fit the planting environment (i.e., selecting faster-growing sources for low-elevation sites and harder sources for high-elevation sites, to develop increased yields).

4. Molecular paternal analysis of orchard seeds

Background

Researchers determine the genetic worth of orchard seedlots by the genetic quality (i.e., growth potential and performance) of the parents, weighted by how much each male and female contributed to the lot. A basic assumption of orchard management is that all parent trees contribute equally to seed crops - that all trees have the same ability to produce cones and pollen, and that there is random mating among all males and females. But trees do not flower at the same rate, and some trees flower either earlier or later than the majority of the trees in the orchard. Both of these factors may skew the genetic makeup of orchard crops.

The amount of seeds contributed to an orchard seedlot by an individual parent tree is relatively easy to estimate by recording the total volume of cones harvested from each tree. Estimating the pollen contributed by each tree is much more difficult. Currently, pollen contributions are

estimated by counting pollen cones. However, these counts may or may not reflect which pollen (male parent) is successful in fertilizing the seed cones (female parent).

Summary

DNA technology recently adapted to forest trees allows researchers to unambiguously identify the male parents of orchard seeds. The method focuses on DNA that is solely inherited through the male parent (i.e., the pollen), but to do this, all parents in the orchard must first be genotyped (or "fingerprinted").

The technology is fast, efficient and increasingly cost-effective. Molecular paternal analysis will improve the accuracy of seedlot ratings (i.e., the amount of genetic gain in each seedlot), help monitor the degree of genetic diversity in the orchard, and measure the amount of contamination by pollen from outside the orchard. Male-inherited genetic markers have been identified for Douglas-fir and lodgepole pine, and research is ongoing to find similar markers for western larch and spruce.

Results or products

Seeds with high genetic worth are more valuable because they hold greater timber volume production potential. Molecular paternal analysis allows researchers to more precisely quantify genetic worth, and to provide seed producers and buyers with greater confidence in the value of the product. (In fact, DNA results are accepted evidence in trade contracts involving sales of orchard seeds.) Ultimately, more precise estimates of genetic worth will lead to more accurate timber volume estimates in the field.

Cooperators

BC Research, Inc. and Seastar Biotech.

RESEARCH SUPPORT

The ministry could not carry out its mandate without the expertise, protocols and hard data provided by the Forest Science Program. At the heart of that science is adherence to principles of sound design, analysis and statistical inference. There is growing recognition that these same principles are critical to the ministry's policy and decision-making processes, so the demand for advice is increasing.

Researchers can be a source of very specialized knowledge and expertise for resolving policy issues. And as researchers work in the policy environment with their clients, improved communications is leading to improved extension.

Managing major projects requires the same skill set as conducting research projects, so it is natural that Forest Science Program researchers are increasingly being asked to take on leadership roles on major policy initiative projects.

1. Biometrics

Link to ministry priority or major initiative

For the best stewardship of the B.C.'s forest and range resources, research undertaken by the ministry must follow sound principles of design and analysis to ensure that results are valid and credible.

Background

Biometrics staff provide technical expertise in experimental design and statistical analysis to ensure the scientific validity of the work being conducted in the Forest Science Program.

Summary

Statistical expertise provided by the biometrics section in 1999/00 helped ministry decision-makers:

- explore the implications of determining and regulating harvest levels by area rather than by volume,
- correlate the ability of silviculture surveys to correctly identify sufficiently restocked or free-growing sites with the expected yields, as projected by TASS (the Tree and Stand Simulator) for lodgepole pine,
- participate in an extensive pilot study in three interior forest regions to examine biogeoclimatic subzones that may be at most risk from the post-harvesting removal of coarse woody debris,
- determine what factors best predict windthrow in wildlife tree patches, and
- assess the accuracy of ecosystem maps.

Results or products

In 1999/00, the Biometrics Section produced two new pamphlets ("ANOVA: Coefficients for contrasts and means of incomplete factorial designs," and "MANOVA: Profile analysis - an example using SAS") and created a website to present the results of the Area-based Allowable Annual Cut Project (www.for.gov.bc.ca/research/areaaac/). Biometrics staff visited regional offices to provide statistical support, and presented a half-day statistics course for the Forest Management Institute of BC.

2. Extension and communications

2a. Forest Science Program websites

Link to ministry priority or major initiative

By increasing access to the best available research information and to the staff expertise of the Forest Science Program, research websites support the ministry's priorities to help clients and other stakeholders resolve resource management problems.



The workshop that was given during the High Elevation Summit was held at the Gavin Lake Forestry Education Centre.

Background

Forest Science Program websites provide ready access to an increasing wealth of information, ranging from extension notes on current management issues, to abstracts from major publications. The sites also include contact lists for staff in various areas of expertise, and maps and information on the large number of research installations that are maintained throughout the province.

Results or products

During 1999/00, the Research Branch reorganized and streamlined its website to make it easier to navigate. The site now includes staff listings, publication lists, valuable links, large-scale biogeoclimatic maps, topical issues, and the 1998/99 Forest Science Program Annual Report.

Regional research websites were expanded and updated with extension notes, abstracts, project information, and other public communications. In addition, the Cariboo Forest Region's Itcha-Ilgachuz and Quesnel Highland Alternative Silvicultural Systems trials were included on the Forest Ecosystem Research Network of sites (FERNS) website maintained by the Canadian Forest Service.

Cooperators

Forest Science Program websites link to other valuable B.C. research information, as well as to national and international research sites. For example, the Research Branch website provides links to B.C. universities with forestry, biology, and environmental studies programs, and to Canadian Forest Service research stations. Links to American universities and U.S. Forestry Research Centres are also provided, as well as links to some international universities and research institutes that offer forestry or environmental information in English.

2b. Extension activities and products

Link to ministry priority or major Initiative

To support sound, integrated resource management and address current and emerging issues, ministry, industry and agency staff must have access to up-to-date knowledge and skills.

Background

Forest Science Program staff and extension specialists disseminate research findings through personal contact (e.g., workshops, field trips and one-on-one consulting services), paper and electronic publications, computer models, and other products. Researchers also participate in a variety of extension events to share research findings with forest resource agencies, industry, and other clients.

Results or products

During 1999/00, Forest Science Program researchers and extension specialists took an active role in workshops and field trips. Topics covered included ecosystem management, remote sensing of stream temperatures, partial-cutting, wildlife, and disturbance ecology. Sixty program publications were produced, on topics ranging from partial-cutting and wetland ecology to old growth and mixedwoods. Program researchers also published numerous papers in symposium proceedings and peer-reviewed professional journals. An evaluation of extension notes was completed to ensure that research extension efforts are meeting client needs.

2c. Extension and research partnerships

Link to mMinistry priority or major Initiative

Extension and research partnerships help the ministry and the Forest Science Program focus extension and research on critical resource management information needs.

Southern Interior Forest Extension and Research Partnership

Background

The Cariboo, Kamloops and Nelson forest regions, along with the Research Branch, are founding members of the Southern Interior Forest Extension and Research Partnership. Partnership staff focus their efforts in ecosystem management on aboriginal forestry, forest practices, and socioeconomics.

Results or products

Research Branch and other ministry staff contributed to a number of benchmark partnership activities during 1999/00, including serving on the board of directors, conducting a client-needs analysis, and holding two workshops. Considerable progress was also made on developing a website, information agreements, an information network, and an electronic publication, the *Journal of Ecosystems and Management*. These partnership efforts have resulted in improved communication and connections among industry, ministry staff, and other government and non-government organizations throughout the southern interior.

Cooperators

There are more than 30 partners involved from the southern interior of B.C., ranging from government agencies and First Nations to environmental groups, communities, industry, and learning institutions.

Northern Forest Research and Extension Partnership

Background

The goals of this northern B.C. partnership are to develop and deliver scientific, indigenous, and experimental knowledge, to facilitate collaboration between partner organizations, and to promote effective extension, practical technologies, and joint research ventures.

Results or products

Forest Science Program and other ministry staff have had an active role on the board of directors during development of the northern partnership. In 1999/00, the partnership incorporated as a society and began the process of hiring an executive director. The partnership also conducted a feasibility study, developed a business plan, and identified priority client information needs.

Cooperators

Stakeholders in the forest industry, government, First Nations, and northern communities endorse this partnership initiative.

Coastal Forest Research and Extension Partnership

Background

The Coastal Forest Research and Extension Partnership is a proposed cooperative of agencies and individuals who need to access and share information relating to sustainable forest management on the B.C. coast.

Results or products

An initial small working group was established during 1999/00 to develop a strategy for creating a formal coastal research and extension partnership. A steering committee, representing a wider group of stakeholders, was formed to further develop the partnership strategy and business plan.

Cooperators

The partnership is now inviting participation, in the Vancouver and Prince Rupert forest regions, from government agencies, industry, educational institutions, and others with an interest in sustainable forest management.

3. Special Projects

3a. Density management guidelines

Link to ministry priority or major initiative

Recent legislation obligated the B.C. forest industry to thin forest stands that regenerate at high densities (e.g., lodgepole pine and hemlock). The deputy chief forester subsequently led an initiative to develop a method of identifying stands of unacceptable density. Forest Science Program staff played a major role in this initiative.

Background

Excessively high or low regeneration densities can affect the volume, quality and value of forest stands, which have the potential to adversely affect the allowable annual cut.

Summary

Guidelines for Developing Stand Density Management Regimes, published during 1999/00,

introduces prescription writers to the concepts of stand development, the rigorous application of economic and investment principles, and forest planning considerations in the context of the objectives of forest owners. It also recommends a structured decision-making process and offers density management planning tools.

TIPSY (Table Interpolation Program for Stand Yield) shows the impact of density management decisions on stand yield, product value and economic return. This software is now used throughout the province to evaluate the effects of different target densities, guide pre-commercial and commercial thinning and evaluate the merits of other silviculture treatments. The principal focus of the guidelines, however, is pre-commercial thinning within the context of timber production.

Results or products

The *Guidelines* are changing the way young stands are managed in B.C. They incorporate underlying principles of stand management to provide a decision framework that is designed to allow flexible decision-making at the site-specific level. Rather than prescribe specific density regimes or default density standards, the *Guidelines* incorporate up-to-date stand density management concepts and information that is essential to the decision process.

Cooperators

The forest industry and the Interior Lumber Manufacturers Association.

3b. Enhanced Forest Management Pilot Project (EFMPP), Invermere Forest District

Link to ministry priority or major initiative

A major part of the Ministry of Forests' mandate is to manage and conserve forest and grassland ecosystems for sustainable use now and in the future. EFMPPs help the forest sector do that by investigating and applying innovative forest management practices in day-to-day operations.

Background

EFMPPs are a cooperative initiative among the forest industry, the Ministry of Forests, Forest Renewal BC, the B.C. Ministry of Environment, Lands and Parks, the academic community, and labour. The Invermere EFMPP set out to develop enhanced forest-level management strategies. A related goal was to improve the effectiveness of new forest inventory and research activities in relationship to those strategies.

Summary

The Invermere EFMPP has fostered the development of computer technology and silviculture planning that optimizes treatments, costs and timber volume over the



At the Siphon Creek mixedwood installation, white spruce is grown under 5,000 stems/hectare of aspen, on the same site as open-grown spruce treatments. White spruce under aspen are significantly smaller in height and diameter than open-grown white spruce.

long term. Both are applicable elsewhere in the province. A comprehensive strategy for restoring fire-maintained ecosystems with frequent stand-maintaining fires has been developed and extended to other parts of the district and province.

EFMPP operational research trials have addressed:

- maintaining soil productivity during harvesting operations,
- partial harvesting in old-growth stands to maintain original structural attributes,
- the economic implications of partial-cutting in old-growth stands and commercial thinning opportunities,
- fire history, to support fire-ecology-based forest ecosystem management in fire-maintained ecosystems, and
- methods to treat Armillaria root disease in calcareous (or chalky) soil conditions.

Results or products

The Invermere EFMPP has confirmed that there are opportunities for innovative forest practices that can coexist with maintaining other forest values.

Cooperators

- B.C. Ministry of Environment, Lands and Parks
- University of British Columbia Centre for Applied Conservation Biology
- J.S. Thrower and Associates Ltd.
- Eagle Vision (a Geographic Information Systems [GIS] company of the Ktunaxa/Kinbasket Tribal Council)
- Pandion Consulting
- Arborecos
- Crestbrook Forest Industries Ltd.
- locan Forest Products Ltd.

3c. Long-term growth and yield field studies

Link to ministry priority or major initiative

Growth and yield estimates are an integral part of silviculture planning and timber supply analyses.

Background

The growth patterns of trees and stands are best understood when they are studied over a long period of time. The most accurate and reliable estimates of the long-term effects of stand and insect management activities are those derived from remeasurement data from permanent sample plots. Data from a wide variety of long-term growth and yield studies, both on the coast and in the interior of B.C., are currently being used to calibrate and validate growth and yield models, and to develop and improve our forest management practices.

Summary

During 1999/00, growth and yield researchers:

- completed a 19-year study at Fish Lake (southeast of Prince George, in the Willow Creek drainage) on the response of severely repressed lodgepole pine to thinning and fertilizing,
- analyzed 40-year data from a partial-cutting trial in the Interior Cedar-Hemlock zone and used the data to validate PrognosisBC,
- analyzed and prepared extension notes on eight-year Douglas-fir data and four-year western hemlock data from thinning and pruning experiments, and
- incorporated fertilization response data into TIPSYP (Table Interpolation Program for Stand Yield).

Results or products

Data from these long-term studies are used to calibrate and validate growth and yield models and also used in timber supply analyses and silviculture planning. Extension notes and research reports provide forest managers with easy-to-read, up-to-date results and recommendations for a variety of stand management activities.

Cooperators

B.C. forest companies.

3d. Spatial timber supply projects

Link to ministry priority or major initiative

Recent spatial analyses have been used in innovative forest management initiatives, considered during Timber Supply Reviews by the chief forester, and are used in the development of higher-level plans by the provincial government.

Background

In the past decade, there have been major developments in the number and type of forest simulation models and Geographic Information Systems (GIS) that can track the flow of wood in a large geographic area. The chief forester uses one such model – Forest Service Simulator (FSSIM) – in his determination of the allowable annual cuts for timber supply areas on a five-year cycle, and spatial models are employed in the Innovative Forest Practices Agreements (IFPAs) and the Enhanced Forest Management Pilot Projects (EFMPPs). Some forest simulation models can also provide estimates of non-timber resources, such as different categories of critical caribou habitat.



The modified stem analysis procedure that is used to generate height-growth curves of young trees.



Long-term growth and yield plots are measured at regular intervals over many years.

Some parts of the B.C. Forest Practices Code require consideration of spatial factors, in that the state of neighbouring stands determines whether a particular stand is available for harvest. Spatial analysis has also been used to forecast the economic effects of various resource management alternatives in regional and subregional plans.

Summary

During 1999/00, researchers studying spatial timber supply worked on a variety of projects, including the following:

- The Tool for Exploratory Landscape Scenario Analysis (TELSA) is a computer tool for exploring the ecological consequences of alternative landscape-level forest disturbance patterns. The model is being applied in the Kamloops Forest Region to develop innovative approaches to landscape planning, by looking for ecologically sound solutions to habitat/timber conflicts.
- Researchers working on the "Analysis of the Policy of Variant Level Old Forest Representation" examined the potential for incremental risk to biodiversity posed by the provincial policy to require old-growth representation at the variant level.
- Researchers improved on an automatic patch/cutblock generator, which will help in spatially explicit timber supply modelling and landscape planning.
- In the "Analysis of Enhanced Resource Development Zones - Timber for the Kootenay Boundary Higher-Level Plan," researchers examined the location and interaction of non-timber values, and calculated the area and location of relatively unconstrained stands in the Nelson Forest Region.

Results or products

Recent spatial forest simulation models and expert reviews of spatial methodologies have been considered by the chief forester during Timber Supply Reviews and evaluation of tree farm licence management working plans.

Cooperators

Spatial initiatives typically involve teams of industry, consultants and government.

HOW TO CONTACT US

We welcome your comments and questions about the Forest Science Program at the Ministry of Forests, and invite you to contact us by telephone, mail, fax or email. Or visit our websites for a list of publications, project summaries, and other information.

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A High-Elevation Summit in the Cariboo Forest Region was attended by researchers from the Forest Science Program, universities and private industry. A field trip was made during the summit to the group selection research site in the Engelmann Spruce-Subalpine Fir zone.